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TRANSUTERINE PHLEBOGRAPHY WITH PARTICULAR REFERENCE TO PELVIC VARICOSITIES

by

N CHIDEKEL and K O EDLUNDH

The present report is complementary to other publications (AHLBERG, BARTLEY & CHIDEKEL 1963 1965 a b 1966 AHLBERG BARTLEY CHIDEKEL & FRITJOFSSON 1966, and CHIDEKEL to be publ) CHIDEKEL, at selective phlebography of the left renal vein has demonstrated that the entire left ovarian vein and some of the pelvic veins were contrast filled in a retrograde direction in one group of women (I) while in another group (II) the ovarian vein was only partially filled The ovarian veins in the patients of group I were significantly wider in comparison to those of group II In only one patient of group II could the visceral pelvic veins be observed their demonstration being due to the selective placing of the tip of the catheter caudal to a pair of competent valves in the ovarian vein The pelvic veins in this patient were smaller than in the majority of the patients in group I It was therefore con sidered to be of interest to perform transuterine phlebography and to compare the patients of groups I and II with respect to the uterine veins and the direction of contrast flow in the ovarian veins

Transuterine phlebography has been described by e g GUILHEM et coll

From Roentgen Department III (Director Docent O Bartley) and the Department of Obstetrics and Gynaecology I (Director Prof S Brody) Sahlgrenska Sjukhuset Gothenburg Sweden Submitted for publication 23 May 1966



Fig 1 Group I Case 6 erect at 5 sec after injection of the contrast med um The veins of the ovar an and uterine plexuses a e wide bilaterally the right ovarian vein is con trast filled but not the left one

Methods The patients were premedicated with *promethazine* chloride and pethidine chloride and placed in the lithotomy position on a tilting table No anesthesia was employed The vagina was desinfected with 0 1 % benzalko nium solution and the cervix grasped with forceps the uterus was probed and the cervical canal dilated if necessary to Hegar 6 HASNER s instrument was employed Air was removed from the cannulas and the metal holder was placed under monitor screen control into the uterine fundus The cannulas had previously been adjusted to project for a maximum of about 4 mm beyond the tip of the metal holder They were inserted into the myometrium and their position was monitor screen controlled by *the injection* of 4 ml Urografin 45 % approximately 150 i u *hyaluronidase* dissolved in 4 ml NaCl 0 9 % solution *were then deposited* in *the* myometrium *A total of 20 ml* of the contrast medium was injected within the course of *about* 5 *sec* with *the* patient supine *The* injection was performed *with the aid* of a pistol type handle attached to two syringes *Three* exposures were made the first at the end of the injection and the others *10 and 60* sec later In all *patients* except one *(group I) the* examination was repeated with *the subject* almost erect (leaning back 10 to 20 the patient not examined *erect* was *supine* with the head end 15 below the horizontal *when the second* injection was performed The dia meter of the uterine veins that were contrast filled in the erect position was

(1951), TOPOLANSKI SIERRA (1958), WEGRYN & HARROW (1960), SCHUSSLER & HEINEN (1963), PALI et coll. (1963) and BUHL & LEFEVRE (1964). The first mentioned investigators placed a cannula in the myometrium of the uterus and injected the contrast medium with an ordinary syringe. This technique very often results in irregular, asymmetric contrast filling of the visceral pelvic veins, the uterus is moreover easily perforated. For these reasons the technique has been modified by other investigators. SCHUSSLER & HEINEN constructed an instrument with four cannulas in a metal holder which is inserted into the uterine cavity, the cannulas then being placed in the myometrium at the desired depth. HAMMEN (1965) made a similar instrument with two cannulas.

The most important indication for transuterine phlebography has been suspected pelvic varicosities. Some authors (TOPOLANSKI SIERRA, PALI et coll.) have stated that this diagnosis can be made on the basis of wide and convoluted veins belonging to the ovarian and uterovaginal plexuses in conjunction with a delayed disappearance of the contrast medium. None of the aforementioned investigators, however, has defined the width of the veins in normal cases, and they present conflicting information on the 'disappearance time' of the contrast medium. PÁLI et coll. reported that the 'disappearance time' may be as great as 3 min in normal cases, while TOPOLANSKI SIERRA gave a maximum figure of 20 sec. On the other hand, the latter author suggested that in certain cases of varicose veins the 'disappearance time' may be normal. Thus, no uniform roentgenologic criteria for the diagnosis of pelvic varicosities by means of transuterine phlebography can be found in the literature.

Material. A random choice of 17 patients, 9 from group I and 8 from group II, was made from the 75 patients who were investigated with left sided renal phlebography (CHIDEKEL). The interval between the two examinations was on the average 12 months. All of the patients were in the fertile years, the mean age was 36 years (range 25 to 45 years). None were pregnant during the interval between the examinations. All of the patients belonging to group I and four of group II had one or more symptoms associated with pelvic varicosities (pain or 'heaviness' in the pelvis, particularly after prolonged standing, secondary dysmenorrhea, and deep dyspareunia). Four patients in group I and three in group II were in the first half of the menstrual cycle while the others in both groups with the exception of one were in the second half. This patient, belonging to group II, had meno metrorrhagia, and the cyclic phase could therefore not be established. The main diagnosis before the roentgen investigation was dolores abdominis in 15 of the patients, menorrhagia in one (group I) and in the remaining patient (group II) meno metrorrhagia.

Table (cont)

Right uterine veins				Contrast filling			
Number		Aver diam (mm)		Ovarian plexus		Ovarian vein	
I 1	I 2	I 1	I 2	Left	Right	Left	Right
1	1	5	4	+	+	+	+
1	3	4	5 3	+	+	+	+
1	1	7	9	−	+	−	−
1	1	6	5	−	+	−	+
0	0			+	+	−	−
2	3	5 0	5 0	+	+	−	+
1	1	7	7	+	+	−	+
2	2	5 0	5 5	+	+	−	+
2	1	4 0	4	+	+	+	+
0	0			+	+	+	+*
1	1	3	3	+	+	+	+
2	1	3 0	3	+	+	+	+
2	1	2 0	2	+	+	+	+
2	2	2 0	3 5	+	+	+	+
2	1	3 5	4	−	+	−	+
1	0	3		+	+	−	+

* The right ovarian vein filled after repositioning of the right cannula

Results

Patients examined erect The uterine plexus in all the patients was bilaterally contrast filled (Figs 1 and 2) In the Table the contrast filling of the ovarian plexuses and of the ovarian veins up to the level of L5 for each patient The numbers of uterine veins and the average diameters as noted by the two investigators as well as the diameter of the left ovarian vein at renal phlebography are also recorded The last mentioned figures were taken from another investigation (CHIDEKEL to be publ) Only those uterine veins that were sufficiently contrast filled for purposes of identification and measurement were included

The variation in width of the uterine veins in a single patient was not more than 1 mm as recorded by investigator 1, while investigator 2 noted variations of 3 mm in two patients and maximally 1 mm in the others The mean values obtained by investigator 1 for the diameter of the uterine veins were 5 3 mm (S^2 = 0 73) in group I and 3 0 mm (S^2 = 0 55) in group II The corresponding values for investigator 2 were 5 6 mm (S^2 = 1 22) in group I and 3 1 mm (S^2 = 1 19) in group II

Table

Roentgenologic findings at transuterine phlebography with patients examined erect — the uterine veins were judged by two investigators designated as I 1 and I 2 in the respective columns

Group	Case	Diameter (in mm) of left ovarian vein at renal phlebography	Left uterine veins			
			Number		Aver diam (mm)	
			I 1	I 2	I 1	I 2
	1	4	3	3	5 3	5 0
	2	6	2	1	4 0	5
	3	7	1	1	7	8
I	4	8	1	1	6	5
	5	9	3	3	5 3	6 3
	6	11	2	2	5 0	5 0
	7	12	0	0		
	8	12	3	3	5 0	5 7
	9	2	1	2	3	2 0
	10	2	2	3	3 5	3 7
	11	2	1	1	3	3
	12	3	1	3	2	2 0
II	13	4	2	1	2 0	1
	14	4	2	1	3 0	5
	15	4	3	3	3 7	4 7
	16	5	2	0	2 5	

measured to the nearest millimetre 1 cm above the level of the cranial part of the acetabulum where these veins course vertically The measurements were made directly from the films by two different investigators CHIDEKEL (investigator 1) and another roentgenologist (investigator 2) The latter did not know the grouping of the various patients

The width of the metal holder was 5 8 mm but its image on the films was in every instance 8 mm The enlargement factor for the central ray was therefore 1 4 at the level of the uterine cavity No correction for enlargement has however been made, direct measurements from the films were employed All the patients received 150 mg penicillin (potassium a phenoxypropyl penicillin) per os 3 times on the examination day and on the following two days

Perforation of the uterus occurred in three patients (one in group I and two in group II) when the examinations were performed in the erect position, the contrast medium passed into the peritoneal cavity No increase in temperature or other reactions occurred in either these or the other patients investigated

The table reveals that antegrade flow in the left ovarian vein in group I was observed only in the two patients with the smallest ovarian vein diameters The diameter of the ovarian veins was 2 mm or 3 mm in four patients of group II in all of these and in two patients with a diameter of 4 mm the ovarian veins were contrast filled in an antegrade direction (Fig 2) The remaining two patients without antegrade flow were among those having the widest ovarian veins in group II i e 4 mm and 5 mm respectively

Comparison of the frequencies of contrast filling of the right and left ovarian veins disclosed a significant difference between the two sides The right ovarian vein was filled initially in 15 of 16 patients or in 93 7 % The corresponding figures for the left ovarian vein were eight out of 16 patients or 50 % (u = 2 75) The left ovarian vein was filled in two out of 8 patients (25 %) of group I and in six of 8 (75 %) of group II This difference is also significant (u — 2 00)

The veins in the left parametrium in Case 11 (Fig 3) were displaced around a circular region about 5 cm in diameter probably due to an expansive process Verification at clinical examination and laparoscopy was not possible because of adiposity Operation has not been performed

Patients examined supine The uterine plexus was contrast filled bilaterally in all the patients The veins of the vesical plexus were filled in 3 patients of group II one bilaterally and two only on the left side None of the other patients from the two groups had any contrast filling of the vesical plexus The right ovarian vein was observed in all patients up to the level of L5 while the left ovarian vein was contrast filled to the same level in four patients of group I (in two of them the contrast filling was noted also when erect) and in the six patients from group II in whom the veins had been filled in the erect position Only the right ovarian vein was demonstrated at the recumbent examination in the one patient in group I who was not investigated erect, while the left ovarian vein was also filled at the second injection of the patient with the head end tilted 15 below the horizontal plane (Fig 4)

The contrast medium remained in the visceral pelvic veins for at least 60 sec after the injection in all the patients irrespective of posture No attempt to estimate the disappearance time was made in this investigation

Discussion

The first problem to be considered was whether or not there was any significant difference in the width of the uterine veins between patients of groups I and II The diameter of the uterine veins at left sided renal phlebographs could be measured in 60 % of cases in group I, but measurement in



Fig. 2. Group II. Case 13, erect, at 10 sec after injection of the contrast medium. The veins of the ovarian and uterine plexuses are narrow; both ovarian veins are filled.



Fig. 3. Group II. Case 11, erect, at 5 sec after injection of the contrast medium. Narrow pelvic visceral veins, those on the left side being displaced, probably by an expansive process.

The differences in diameter between the groups, according to the two investigators, are highly significant (t = 12.41 and 7.19, respectively). The vesical plexus was bilaterally contrast filled in 6 patients of each group, i.e. in 12 of the 16 patients; neither side was outlined in one patient of group I and only the left side in the remaining three patients. In all instances except one the diameter of the vesical veins varied from the uterine veins by no more than 2 mm. The exception comprised a patient of group II in whom two veins of the vesical plexus on the left side were 10 mm wide while the vesical veins on the right side were no wider than 2 mm; the latter value was about the same as that noted for the uterine veins bilaterally.

With the technique employed, the contrast filling of the ovarian veins could be estimated only up to the upper surface of L 5. The right ovarian vein was in all cases filled at least to this level, in one patient, however, only after changing the position of the cannula in the right part of the myometrium. The left ovarian vein was filled to the same level in two patients of group I (Cases 1 and 2) and in six patients of group II (all except Cases 15 and 16).

de direction although the contrast medium has a higher specific gravity than blood The passage of the contrast medium through the ovarian veins occurred within a few seconds with both techniques, and these findings clearly indicate that the direction of flow of the contrast medium is the same as that of blood

The results of the investigations with selective renal and transuterine phlebography imply that a relationship exists between the direction of flow in the left ovarian vein, the width of this vessel and the width of the uterine veins When there is retrograde flow in the ovarian vein this vein and the uterine veins are significantly wider than in cases with no retrograde flow A detailed analysis of the results indicates that there are two categories of patients with contrasting roentgenologic findings In one of them the contrast medium passed in a retrograde direction through wide (> 6 mm) ovarian veins these patients also had wide (> 4 mm) uterine veins These roentgenologic findings are proposed as diagnostic criteria of pelvic varicosities The other category consists of patients in whom no retrograde flow was demonstrated, the ovarian and uterine veins were not wider than 4 mm or 5 mm respectively With these patients there was no roentgenologic basis for the diagnosis of pelvic varicosities It has been maintained in the literature that the so called pelvic congestion syndrome represents a preliminary stage of pelvic varicosities It seems reasonable to as ume that pelvic varicosities develop gradually If this is true there should be cases in the present material which from the roentgenologic viewpoint could be placed midway between the two aforementioned well defined categories There were in fact four borderline cases In two patients retrograde as well as antegrade direction of flow was demonstrated through ovarian veins that were respectively 4 mm and 6 mm wide the maximum width of the uterine veins was 6 mm in these patients In two patients neither retrograde nor antegrade flow could be demonstrated these patients were among those without retrograde flow who had the widest ovarian veins (4 mm and 5 mm) and in whom the uterine veins were 2 mm to 5 mm wide It is probable that in these four instances there was a very small pressure gradient or none at all at the orifice of the ovarian vein That a minor change in the pressure gradient can change the direction of contrast flow was shown in Case 17 which was examined only supine The left ovarian vein was filled when the head end was 15 below the horizontal but not when the patient was lying horizontal

Earlier investigators who have used the transuterine technique for estimating the presence of pelvic varicosities have not touched upon the direction of flow of the contrast medium in the ovarian veins and no limit for the normal width of the pelvic veins has been suggested The so-called disappearance time of the contrast medium has been employed as indicator of pelvic varicosi



Fig 4 Group I Case 17 supine at 5 sec after injection of the contrast medium a) The ovarian and uterine venous plexuses are wide bilaterally no contrast filling of the left ovarian vein with patient horizontal b) With head end 15 below the horizontal both ovarian veins are filled

group II was not possible because of only partial retrograde contrast filling of the ovarian vein Comparison of the widths of the uterine veins, measured at renal and transuterine phlebography, disclosed no differences greater than 1 mm CHIDEKEL has pointed out that a relationship as regards width existed in group I between the ovarian and uterine veins The diameter of the uterine veins could be determined for group II with the transuterine technique The width of the uterine veins varied between 4 mm and 9 mm in group I and between 2 mm and 5 mm in group II The difference between the groups was significant Thus, differences in width of the uterine as well as the ovarian veins exist between groups I and II

A further problem was whether or not the direction of flow of the contrast medium was the same as that of blood By definition for group I, the left ovarian vein was entirely filled in a retrograde direction by contrast medium injected into the renal vein with the patient erect When the contrast medium was injected into the uterus, a statistically significant majority of patients in group II, as opposed to group I, had contrast filling of the left ovarian vein in an antegra

SUMMARY

Transuterine phlebography was carried out in 17 patients supine and also in the erect position in 16 of them The width of the uterine veins was compared in subjects with and without retrograde flow in the left ovarian vein A comparison between left-sided renal phlebography and transuterine phlebography indicated that the former method may be preferable for establishing a diagnosis of pelvic varicosities

ZUSAMMENFASSUNG

Transuterine Phlebographie wurde an 17 liegenden Patienten ausgeführt von denen 16 auch stehend untersucht wurden Ein Vergleich zwischen der Weite der Venen in Fällen mit und ohne Rückfluss in der linken Ovarialvene deutete darauf hin dass linksseitige renale Phlebographie der transuterinen Phlebographie für die Diagnose von Beckenvarizen vorzuziehen ist

RÉSUMÉ

Les auteurs ont pratiqué une phlébographie transutérine en décubitus chez 17 femmes dont 16 ont aussi été examinées debout Ils ont comparé le diamètre des veines utérines dans les cas avec et sans reflux dans la veine ovarienne gauche La comparaison entre les résultats de la phlébographie rénale gauche et de la phlébographie transutérine indique que la phlébographie rénale soit préférable pour la recherche de varices pelviennes

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ties The present authors have not examined the latter factor in detail but it was noted that the contrast medium always persisted for at least 60 sec after the start of the injection *whether the patients were supine or erect As opposed* to TOPOLANSKI SIERRA, the present authors could not with the 'disappearance time' differentiate between patients with and without pelvic varicosities PALI et coll gave the normal 'disappearance time' as being not above 3 min Whether or not this figure is correct cannot be decided from this investigation, exposures were not made later than at 60 sec in order to limit the gonadal dosages

If the transuterine technique is to be employed for diagnosis of pelvic varicosities, the results suggest that a more reliable basis for estimation will be *obtained if the examination is carried out with the patient erect and attention* paid to the direction of flow in the ovarian veins and the width of the uterine veins instead of to the 'disappearance time The direction of flow in the ovarian vein is probably estimated better at selective renal phlebography than at transuterine phlebography, since with the latter method the failure of antegrade flow may be due to unsatisfactory positioning of the cannula in the myometrium

It therefore may be stated that the diagnosis of pelvic varicosities will usually be more reliable with selective renal phlebography than with transuterine phlebography The former method has been employed in 75 females with*out complications, while uterus perforation occurred in three of 17 patients* investigated with the transuterine technique So even from the point of view of complications selective renal phlebography would seem to constitute the technique to be preferred The examination should be performed with the patient erect The region to be radiographed should extend from the renal vein to the level of S1 When an ovarian vein > 6 mm wide is contrast filled in a retrograde direction, pelvic varicosities probably exist Further examination is then unnecessary, and the ovaries need not be exposed to direct radiation When retrograde flow occurs in a narrower ovarian vein the examination may be extended to include the uterine veins If at left sided renal phlebography a retrograde direction of flow cannot be demonstrated in the ovarian vein, but pelvic varicosities are still strongly suspected, right sided renal phlebography or transuterine phlebography may be the method of choice

Pelvic varicosities probably occur secondary e g to obstruction of flow in the pelvic veins caused by expansive processes compressing the larger drainage veins If retrograde flow in the left ovarian vein does not occur simultaneously, the pelvic varicosities cannot be diagnosed by means of left sided renal phlebography Under such circumstances other methods, in addition to transuterine phlebography, with simultaneous compression of the inferior vena cava, may be of value

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UPPER URINARY TRACT DUPLICATION ASSOCIATED WITH ECTOPIC URETEROCELE IN CHILDHOOD AND INFANCY

by

ERIK LUNDIN and WEBSTER RIGGS

Ectopic ureteroceles usually occur in the female infant and are, with few exceptions associated with ipsilateral complete upper urinary tract duplica tion The ureter that bears the ectopic ureterocele almost always drains a dilated upper renal pelvocalyceal system often not demonstrated at urography

Great variety exists in the appearance of the pelvocalyceal *systems in this* disorder Particular deformities of the lower system have been considered typical of changes secondary to ectopic *ureteroceles* These abnormalities have been investigated in detail to determine the causative mechanism The main reasons for the investigation were

1 To determine to what extent the distortion of the lower system may be caused by dilatation of the upper system and to what extent a preformed morphologic structural abnormality exists

2 As the ureterocele is occasionally in the midline to determine which upper tract if any is duplicated

3 As the lower pelvocalyceal system is usually not definitely deficient in

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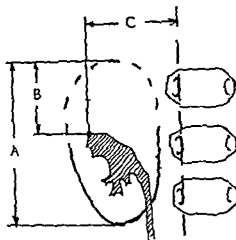


Fig 1 Schematic illustration of the typical appearance of a kidney with a dilated and non filled upper pelvis The upper pole is somewhat large and indistinctly outlined The letter A indicates the renal length B the distance from the upper pole to the most cephalad of the contrast filled calyces and C the pedicle calyx distance — In cases with duplicated upper urinary tract the ratio A/B is less than 2 6 1 (according to NILSSON 1962) In normal cases without duplication the ratio A/B is more than 3 3 1

I Thirty one cases of duplication with non functioning or only a slightly functioning upper renal system associated with ectopic ureterocele

II Thirty one cases of complete duplication without ureterocele in which both systems functioned normally

III Eighteen of the group I cases in which the ureterocele had been unroofed and obstruction more or less relieved permitting a postoperative study of the lower system

The cases were reviewed with special attention to the lower pole system but the anatomy of the entire kidney was also studied Frontal lateral and oblique views were obtained at urography and voiding urethrocystography while the topographic relationships were studied supine without ureteral compression Most of the postoperative cases were examined more than once so that the regression of changes after subsidence of dilatation infection and edema could be evaluated

Differences between the tabulated findings in groups I and II were interpreted as being due to dilatation and infection of the unfilled upper system Constant similarities between these groups were thought to represent preformed changes independent of dilatation and infection

Results

Group I consisted of twenty eight girls and three boys, the youngest of which was two months and the oldest eleven years Two-thirds of the cases were under three years approximately half the number of cases had bilateral urinary duplication and two cases had bilateral ureteroceles The anatomy of the kidney including the lower renal pelvis as well as the lower ureter was carefully analysed in this group

Table 1

Roentgen findings in examination of the kidney in 62 cases divided into two groups each one comprising 31 cases of duplication

	Group I — Non filling of upper system	Group II — Both systems normally functioning
Indistinct upper pole	13	8
Renal length more than mean (HODSON et coll and BAGHDASSARIAN GATEWOOD et coll)	26	27
Renal length/distance upper pole to upper calyx of lower pelvis less than 2 6 1 (NILSSON)	29	27
Abnormal shape	9	—
Displacement along transverse axis	3	—
Rotation about sagittal axis	1	—
Rotation about transverse axis	3	—

Table 2

Roentgen findings in examination of the lower pelvocalyceal system in 62 cases divided into two groups each one comprising 31 cases of duplication

	Group I — Non filling of upper system	Group II — Both systems normally functioning
Pedicle/calyx distance ratio more than 1 5 1	12 (out of 16)	11 (out of 20)
Lateral displacement of pelvic ampulla and pelvo ureteric junction	18	1
Flat cephalad outline of pelvis	15	2
Lateral deviation of cephalad minor calyces	25	11
Short cephalad major calyx	20	27
Lower pelvis deficient in size and/or number of calyces	10	15

calyces, and the upper renal pole is often indistinctly outlined, the lower system may be mistakenly interpreted as the complete system

4 The abnormal appearances of the lower system are occasionally mistaken for neoplastic changes in the upper pole of the kidney

Methods We have approached the analysis by comparing the deformed, lower system with that of a normally functioning, duplicate kidney, in which both the upper and lower systems were outlined Three groups have been studied





a b

Fig 3 Same case as in fig 2 No urinary in fections after unroofing of the ureterocele Voiding urethrocystography 4 years after operation a) Complete reflux filling of a wide ectopic ureter and pelvis no urinary infections after unroofing of the ureterocele b) The ectopic ureter empties into the upper part of the urethra

indicative of duplication and a non functioning upper pole (Fig 1) In 29 of our cases this ratio was less than 2 6 1 In normal cases without duplication the ratio is more than 3 3 1

An unusual shape often caused by an enlarged upper pole was noted in 9 cases

In no case was any obvious displacement of the kidney along its longitudinal axis observed Displacement along the transverse axis in a lateral direction was evident in 3 cases and in all these the dilatation of the upper renal pelvis was extreme

Little significant rotation of the kidney about its axis was apparent Lateral views disclosed rotation of the lower part of the kidney anteriorly about the transverse axes in only 3 cases in most of the others the upper system lay directly cephalad to the lower

The lower pelvocalyceal system (see Table 2) Measurements between certain defineable points and appraisement of some details in the pelvis are given in

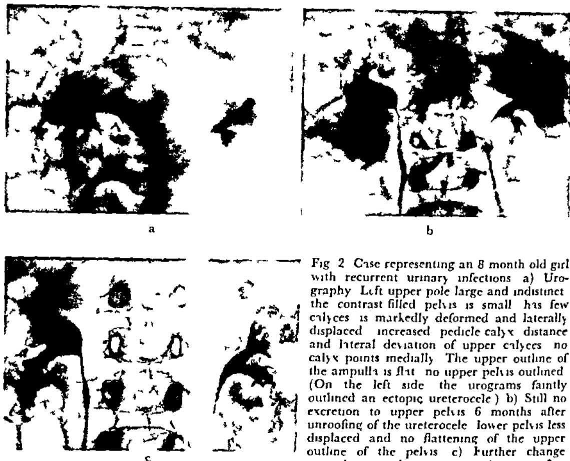


Fig 2 Case representing an 8 month old girl with recurrent urinary infections a) Urography Left upper pole large and indistinct the contrast filled pelvis is small has few calyces is markedly deformed and laterally displaced increased pedicle calyx distance and lateral deviation of upper calyces no calyx points medially The upper outline of the ampulla is flat no upper pelvis outlined (On the left side the urograms faintly outlined an ectopic ureterocele) b) Still no excretion to upper pelvis 6 months after unroofing of the ureterocele lower pelvis less displaced and no flattening of the upper outline of the pelvis c) Further change towards normal appearance 4 years after operation especially with respect to the deviation of the upper calyces See l o fig 3

The kidney (see Table 1) All of the parameters of the kidney are dependent upon demonstrating the renal contours These are often indistinct due to inflammatory reaction and/or normally scant perirenal fat Superimposed intestinal gas may also make it difficult to observe the outline Measurements were made in many cases in group I by estimating the upper pole outline after examining subsequent studies

Renal length was compared with normal childhood standards for each age as devised by HODSON, DREWE, KARN & KING (1962), and recently corroborated by BAGHDASSARIAN GATEWOOD GLASSER & VANHOUTTE (1965) Twenty six of 31 cases exceeded the mean value, with five exceeding one standard deviation

The length of the upper pole was considered in relation to the entire renal length NILSSON (1962) stated that when the ratio *renal length/distance from upper pole to most cephalad of contrast filled calyces* is less than 2 6 1 this is highly



a

Fig 4 a) Urography The ampulla of the lower pelvis of the right kidney is displaced laterally but the upper outline is not flat the upper major calyx is short and the upper calyces deviate laterally b) Urethrocystography before operation Reflux to both renal pelves on right side the upper pelvis is small and medially placed its ureter is wide and tortuous



b

at about forty degrees (Figs 2 and 4) The cephalad major calyx was unusually short in 20 cases (Fig 4) and the lower pelvis appeared deficient in size and number of calyces in 10 cases (Fig 2) The deformity of the lower pelvis was associated with change in position and shape of the kidney only in extreme cases

Ureters (see Table 3) No typical pattern of distortion or displacement of the normally inserted (orthotopic) ureter was apparent The tortuosity and dilatation of the adjacent ectopic ureter had a variable effect on its orthotopic companion causing medial displacement in 6 cases and lateral displacement in another 6 cases The most common effect was lateral displacement of the cephalad part of the ureter at the pelvo-ureteric junction (Fig 5) Dilatation of the orthotopic ureter and pelvis was evident in 7 cases

Reflux into the ectopic ureter occurred relatively often in preoperative voiding urethrocystograms (11 out of 25 cases) (Fig 4) Reflux in some of the cases was thought to be via a communication with the bladder from spontaneous rupture of the ureterocele Reflux into the orthotopic ureter occurred in 9 out of 25 cases

Table 3

Roentgen findings in examination of the ipsilateral ureters in 31 cases of duplication with unfilled upper system (group I)

	Number of cases
Medial displacement of orthotopic ureter	6
Lateral displacement of orthotopic ureter	6
Dilatation of orthotopic ureter and pelvis	7
Reflux into ectopic ureter	11 (out of 25)
Reflux into orthotopic ureter	9 (out of 25)
Blurred psoas muscle	5

Table 4

Roentgen findings in examination of the lower pelvocalyceal system after unroofing of the ureterocele in 18 cases

	Number of cases normal on preoperative examination	Cases abnormal on preoperative examination	
		Number of cases with no change after operation	Number of cases with improvement after operation
Pedicle/calyx distance ratio	—	6	12
Lateral displacement of pelvic ampulla and pelvo-ureteric junction	3	6	9
Flat cephalad outline of pelvis	9	1	8
Lateral deviation of cephalad minor calyces	4	8	6

Table 2. They served the purpose of analysing the presumed deformity of the lower pelvis.

The distance between the most cephalad minor calyx and a line joining the medial borders of the nearest spinal pedicles was measured and compared with the distance on the opposite side (pedicle-calyx distance ratio) (Figs 1 and 2); this was done to eliminate the influence of growth. The ratio was calculated in 16 cases with unilateral duplication and was over 1.5:1 in 12 cases.

The ampulla of the lower pelvis and the region of the pelvo-ureteric junction appeared to be definitely displaced laterally in 18 cases and the normally convex cephalad portion of the ampulla was flattened in 15 cases (Fig. 2).

The most cephalad minor calyces deviated laterally in 25 of the cases, with the angle formed by the long axis of the spine and the respective major calyx



a



b

Fig 4 a) U ography The ampulla of the lower pel is of the r ght kidney is d splaced laterally b t the upper outl ne i not flat the upper major calyx s short and the upper calyces devi te laterally b) Urethrocysto graphy before operat on Reflux to both renal pel es on r ght ide the upper pel is is small a d medially placed its ureter i wide nd tortuous

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Fig 5 Bilateral upper urinary tract duplication and a large left sided ectopic ureterocele a) Before operation The left pelvo ureteric junction and the concave upper part of the ureter are displaced laterally on both sides the upper major calyx is *short and wide and the upper calyces deviate in* lateral direction no excretion to the left upper pelvis b) One year after unroofing of the ureterocele Displacement of the lower pelvis and deformity of the pelvo ureteric junction have diminished function of the upper pole of the kidney is restored and the duplicate pelvis is visible

Blurring of the ipsilateral psoas muscle associated with splinting of the spine was sufficiently obvious in five cases to suggest a superimposed dilated ureter and periureteritis

Group II (see Tables 1 and 2) was similar to group I in respect to increased renal length, large upper pole, normal position of the entire kidney and angle between the major calyx and the spine, which in the normal cases was also about forty degrees *An important observation was that a short cephalad* major calyx occurred even more frequently in the normal duplications than in *the cases of group I*

*The major differences between groups I and II occurred in lateral displace*ment of the lower pelvis and flattening of its cephalad portion These changes were seldom observed in the normal group A deviation of the upper calyces *in the abnormal group was more frequent (Figs 5 and 6)*

As to group III (see Table 4), most of the cases were treated initially by unroofing of the ureterocele, allowing free reflux into the involved ureter *Partial function returned in most cases and the upper system became outlined* (Fig 5) Reflux was less common postoperatively into the orthotopic ureter

Attention was centered on the lower system in the postoperative cases almost all *in this group displayed some general improvement but in eight of* nine cases with a flattened renal pelvis the improvement was obvious

Discussion

ERICSSON (1954) classified ureteroceles into simple and ectopic forms He stressed that most childhood ureteroceles are of the ectopic type producing a large intravesical bulge of a dilated ectopic ureter inside the muscular wall of the bladder base The ureter in these cases is ectopic in that its orifice lies in or distal to the bladder neck In contrast the simple ureterocele commonly seen in adults of both sexes, usually presents as a small intravesical protrusion around an essentially normally situated ureteric orifice giving the typical roentgenologic cobra head appearances DORST CUSSEN & SILVERMAN (1960) have also stressed the importance of ectopic ureteroceles as a source of urinary tract infection in early childhood or infancy

RUDHE (1948) ERICSSON (1954) KJELLBERG ERICSSON & RUDHE (1957), and WILLIAMS (1958) have reported upper urinary tract abnormalities in ureteroceles Once a ureterocele is considered likely a supernumerary pelvis should always be sought in the upper pole of the kidney The lower pelvis is described as depressed with deformation of the upper group of calyces

As mentioned previously NILSSON (1962) has investigated the size of the upper pole and introduced the ratio between the interpolar distance and the distance from the upper pole to the demonstrated upper calyx in the lower pelvis When the ratio is less than 2 6 1 it is very likely that urinary tract duplication with a non functioning upper pole exists while a ratio of more than 3 3 1 makes a heterotopic pelvis unlikely SIDAWAY (1962) pointed out that the kidney is often large with a prominent large upper pole and a deficiency in the number of calyces in the displaced lower pelvis may occur A selectively enlarged upper pole has also been mentioned by GRISCOM (1965)

The mechanism behind the deformity of the kidney and lower pelvis has been discussed only briefly KJELLBERG et coll (1957) stated that dilatation of the ureter and pelvis may decrease after unroofing of the ureterocele but only rarely regress entirely Vesico ureteral reflux which regularly appeared after unroofing was considered as one of the factors responsible for incomplete regression (Fig 3)

The present authors like others have observed that the renal length was increased but this was found also to apply to normal kidneys with duplicate pelves A reduction of the parenchyma surrounding the upper pelvis seemed to be present in most of the abnormal kidneys This reduction tended to eliminate the effect of dilatation only in a few abnormal cases was the dilatation so marked that the upper pole was enlarged When the dilatation of the upper pelvis was extreme lateral displacement of the entire kidney was observed Other displacements or rotations of the kidney were rare The dilated upper

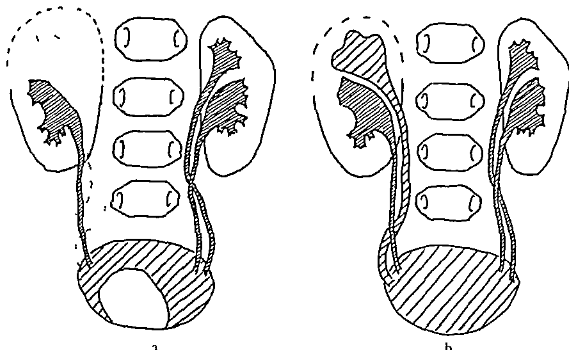


Fig. 6. Schematic illustration of an average case with bilateral duplication of the upper urinary tract and unilateral ectopic ureterocele pre- and postoperatively. a) Before unroofing of the ureterocele: no excretion to the dilated upper pelvis is discernible; the lower pelvis is displaced laterally and its cephalad outline is flat; the upper calyces deviate laterally. b) After unroofing: slight excretion and reflux to the upper pelvis; regression of hydronephrosis; less displacement and deformity of the lower pelvis. Characteristically, the upper major calyces of the somewhat small lower pelvis are short and wide.

pelvis was situated in immediate proximity to the lower pelvis in most of the present cases and only an internal derangement of the renal architecture was apparent.

The best way to define the internal derangement is, as previously mentioned, by considering the form of the lower pelvis. We have been able to confirm all earlier observations regarding the lower pelvis and would add that the ampulla and pelvo-ureteric junction are displaced laterally in the kidney and that the upper border of the ampulla is often flat. These two last details are the main features that distinguish abnormal from normal duplications. It seems that most other characteristics of the lower pelvis are mainly preformed structural abnormalities. Unlike HINMAN (1962), we could not demonstrate any rotation of the kidney around its sagittal axis.

Contrary to other reports, reflux into the ectopic ureter occurred fairly often in pre-operative voiding urethrocystography. Reflux in some of the cases was via a communication with the bladder after spontaneous rupture of the ureterocele.

After unroofing of the ureterocele the cephalad border of the lower pelvis generally became more normal

Special problems concern the cases in which the upper pelvis is very small and medially placed, or in which the narrow ureter terminates blindly in the upper medial part of the kidney These cases presented few divergences from those of the normal kidney with a single pelvis

Considering all the factors mentioned differentiation of renal pelvis duplication in ureteroceles from other renal or extrarenal expansive processes should not be difficult Only one case of the present series in which strong dilatation of the upper renal pelvis and marked lateral displacement of the kidney were present was misinterpreted as being one of a new growth

Conclusions

Duplicate kidneys with an upper pelvocalyceal system not demonstrable by urography and associated with ectopic ureteroceles tend to be larger than the average kidney with a single pelvis (cf Fig 6) The lower system is usually situated more caudad causing the upper pole to appear relatively large Since these findings depend upon delineating the frequently indistinct renal contours observation of changes in the contrast filled lower pelvocalyceal system is more diagnostically rewarding The most cephalad minor calyces of the lower system were found to deviate laterally in 25 out of 31 cases the respective major calyx being short and wide in twenty of the cases The distance between the most cephalad minor calyx and the spine was generally increased The normally convex cephalad portion of the renal pelvis was often flattened with the pelvo ureteric junction displaced laterally

A study of 18 cases after unroofing of the ectopic ureterocele disclosed decreased lateral displacement of the lower pelvis and considerably less flattening of its cephalad convexity these changes were therefore considered to be due to dilatation of the non functioning upper system

A study of 31 normally functioning duplicate kidneys revealed similar characteristics of increased length a relatively long upper pole and a short cephalad major calyx These changes were consequently thought to represent a preformed morphologic abnormality independent of pressure from the dilated upper system

Since reflux into the ureterocele bearing ureter occurred in 11 out of 25 preoperative voiding urethrocystograms this procedure is thought to be of value in the diagnosis

Acknowledgement

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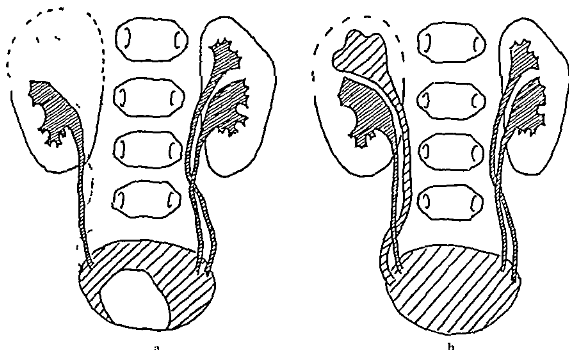


Fig 6 Schematic illustration of an average case with bilateral duplication of the upper urinary tract and unilateral ectopic ureterocele pre and postoperatively a) Before unroofing of the ureterocele no excretion to the dilated upper pelvis is discernible the lower pelvis is displaced laterally and its cephalad outline is flat the upper calyces deviate laterally b) After unroofing slight excretion and reflux to the upper pelvis regression of hydronephrosis less displacement and deformity of the lower pelvis Characteristically the upper major calyces of the somewhat small lower pelvis are short and wide

pelvis was situated in immediate proximity to the lower pelvis in most of the present cases and only an internal derangement of the renal architecture was apparent

The best way to define the internal derangement is, as previously mentioned, by considering the form of the lower pelvis We have been able to confirm all earlier observations regarding the lower pelvis and would add that the ampulla and pelvo ureteric junction are displaced laterally in the kidney and that the upper border of the ampulla is often flat These two last details are the main features that distinguish abnormal from normal duplications It seems that most other characteristics of the lower pelvis are mainly preformed structural abnormalities Unlike *Hinman (1962), we could not demonstrate any rotation* of the kidney around its sagittal axis

Contrary to other reports, reflux into the ectopic ureter occurred fairly often in pre operative voiding urethrocystography Reflux in some of the cases was via a communication with the bladder after spontaneous rupture of the ureterocele

After unroofing of the ureterocele the cephalad border of the lower pelvis generally became more normal

Special problems concern the cases in which the upper pelvis is very small and medially placed or in which the narrow ureter terminates blindly in the upper medial part of the kidney These cases presented few divergences from those of the normal kidney with a single pelvis

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SUMMARY

The appearances of the upper urinary tract associated with ectopic ureterocele in childhood and infancy have been studied in a material of 31 cases and compared with normally functioning duplicate kidneys An explanation is given as to why several of the features previously considered typical of the abnormal lower renal pelvis in ureteroceles were also present in the normal duplicate kidneys

ZUSAMMENFASSUNG

Das Rontgenbild der oberen Harnwege wurde in 31 Fallen mit ektopischer Ureterozele bei Kindern und Kleinkindern studiert und mit Fallen mit normal funktionierenden Doppelnieren verglichen Es wird erklart warum mehrere Veranderungen an den abnormalen unteren Nierenelementen die bisher typisch für die Ureterozele galten auch normalerweise *bei Doppelnieren zu finden sind*

RÉSUMÉ

Les auteurs ont étudié les aspects des voies urinaires supérieures dans les ureterocèles ectopiques de l enfant et du nourrisson dans une série de 31 cas et les ont comparés aux reins dédoublés fonctionnant normalement Ils expliquent pourquoi plusieurs des caracteres considérés comme typiques du bassinet rénal inférieur anormal dans les uretérocèles existent aussi dans les reins dédoublés normaux

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FROM THE DEPARTMENT OF RADIOLOGY (DIRECTOR PROF H TACHIIRI) OSAKA UNIVERSITY SCHOOL OF MEDICINE OSAKA, JAPAN

AORTITIS SYNDROME WITH SPECIAL REFERENCE TO PULMONARY VASCULAR CHANGES

by

T KOZUKA T NOSAKI K SATO and K IHARA

The condition in which pulses in the arms and neck are absent or weak has generally been called the aortic arch syndrome Pulseless disease (SHIMIZU & SANO 1948) is included in this syndrome and since it has a predilection for young females it has been described as young female arteritis by ROSS & MCKUSICK (1953) It is well known that not only the brachiocephalic arteries but also the thoracic aorta and the abdominal aorta with its main tributaries may be involved INADA et coll (1962) proposed the term atypical coarctation of the aorta and pointed out that the condition belongs to the same category as pulseless disease H UEDA et coll (1963) suggested the term aortitis syndrome to indicate such a wide distribution It seems that pulseless disease atypical coarctation of the aorta and the aortitis syndrome or aortic arch syndrome partially overlap Though characteristic clinical signs are present in the disease significant roentgenologic changes are also evident The angiographic findings are of course conclusive but conventional roentgenography may also be of importance (IINUMA 1961 KOZUKA et coll 1966) The roentgenologic diagnosis may even precede the clinical diagnosis in some instances

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a



b

Fig 1 Woman aged 34 a) Aneurysmal dilatation of the entire thoracic aorta irregular contour enlargement of the heart narrowing of the segmental and peripheral pulmonary vessels in the upper part of the right lung b) Constriction of the proximal part of the right pulmonary artery and obstruction of the right upper lobe artery narrowing irregular contour and course of the arteries in other parts of the lung slight dilatation and tortuosity of the left pulmonary artery

In addition to the extensive lesions of the systemic arteries pulmonary vascular changes may be present and be revealed by pneumoangiography The changes now to be reported are often overlooked

Material and Methods Thirty five cases of the aortitis syndrome were reviewed Diagnostic procedures included conventional radiography of the chest and intravenous or retrograde aortography in all the cases and pneumographs in 16 cases

Pneumoangiography was performed by the injection of contrast medium directly into the right atrium or intravenously Percutaneous retrograde aortography was indispensable for detecting the location and the extent and character of the involvement of the systemic arteries Intravenous aortography was used only in those cases in which retrograde aortography had been unsuccessful or did not seem to be indicated No serious complications during or after the procedures were encountered

The sex and age distribution of the cases were as follows

Age in years	Under 19	20—29	30—39	Total
Males	0	4	0	4
Females	7	16	8	31
Total	7	20	8	35

The patients were all Japanese In all the patients, pulses were weak or absent in the arms and neck

Results

Conventional roentgenographic findings Dilatation of the aorta and the irregular contour of the descending aorta which serve as direct signs of aortitis were present in 30 cases Widening of the pulmonary artery occurred in many of the cases Irregular narrow pulmonary vessels were common findings Dilatation of the vessels was present in only two cases and in these there was marked enlargement of the heart with left heart failure Decreased or sparse lung vascularity was observed in 16 cases This was usually evident in the upper part of the lung and was most apparent if the area extended over more than one pulmonary segment This phenomenon was without doubt caused by stenosis or obstruction of the main or segmental arteries (Figs 1a 2a 3a) Tuberculous lesions were detected in 8 cases, in these induration but no activity was evident



a



b

Fig 1 Woman aged 34 a) Aneurysmal dilatation of the entire thoracic aorta irregular contour enlargement of the heart narrowing of the segmental and peripheral pulmonary vessels in the upper part of the right lung b) Constriction of the proximal part of the right pulmonary artery and obstruction of the right upper lobe artery narrowing irregular contour and course of the arteries in other parts of the lung slight dilatation and tortuosity of the left pulmonary artery

Pneumoangiography The right main pulmonary artery failed to fill in the most severe case which has previously been reported upon Various degrees of narrowing and rigidity of the main pulmonary artery were present in four other cases Constriction of the proximal part of the right main pulmonary artery with no contrast filling of the artery to the right upper lobe, is shown in Fig 1b and localized narrowing of the intermediary trunk of the right pulmonary artery is demonstrated in Fig 2b Stenosis of the segmental branches was evident in six cases Marked narrowing and obstruction of the right upper lobe artery may be seen in Fig 3b Narrowing and irregularity of the peripheral branches were also present in all these cases In a further six cases these changes in the peripheral branches were the only abnormalities observed The angiographic changes observed seem to correspond to findings in conventional films

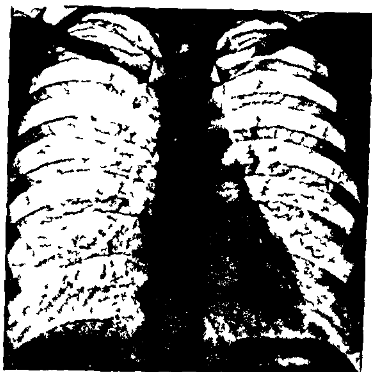
Aortographic findings The irregularity of the contour of the aorta, with or without narrowing is characteristic and pathognomonic of the disease All the cases had narrowed or occlusive lesions involving one or more of the arteries arising from the aortic arch Dilated and tortuous bronchial arteries were demonstrated in the cases that had markedly stenosed segmental pulmonary arteries

Discussion

The aortitis syndrome is considered to fall in the same category as pulseless disease and to imply more extensive lesions than the latter Since the changes are not located in the brachiocephalic arteries alone the term 'pulseless disease does not necessarily indicate their nature Furthermore the stenotic lesions are found not only in the major branches of the aorta but also in the aorta itself in almost all the cases This was the reason why the present authors have previously used the term 'atypical coarctation of the aorta However we recently encountered a case in which no stenotic lesion of the aorta was demonstrated, in spite of generalized dilatation and irregularity of the thoracic aorta with narrowing and obstruction of the brachiocephalic arteries Therefore the term the atypical coarctation of the aorta seems unsuitable Some cases may even show signs of aneurysm of the aorta

The direct conventional roentgenologic indications of the aortitis syndrome are irregular contour of the descending aorta associated with a rigid or irregular outline of the inner surface of the aortic wall, with or without narrowing of the lumen at aortography

A lesion in the pulmonary circulation similar to one in the systemic arteries has been demonstrated at post mortem investigations by OOTA (1940) FROVIG



a



b

Fig 2 Woman aged 37 a) Irregular outline of the descending aorta poor lung markings in upper part of both lungs b) Localized narrowing of the intermediate trunk of the right pulmonary artery few vessels widely interspaced in middle part of the right lung narrowing of the peripheral branches in both lungs

& LOKEN (1951) M UEDA et coll (1951) TAKEDA et coll (1961), and by NASU (1963) Changes were evident in all the pulmonary arteries in the conventional roentgenograms of the chest and were confirmed by pneumoangiography The characteristic findings consist of an area with sparse and narrowed vessels, and contour irregularity in the peripheral branches High voltage roentgenography is valuable in demonstrating vascular changes as well as irregularity in the contour of the descending aorta Widening of the main stem of the pulmonary artery would seem to reflect the pulmonary vascular changes the severity of which are not always related to the systemic vascular changes

Only a few cases of pulseless disease with roentgenologic evidence of involvement of the pulmonary arteries have been reported in the literature (TAMAKI 1958 IINUMA 1961 JUDGE et coll 1961 MCKUSICK 1962 KOZUKA et coll 1966) The roentgenologic appearances of the peripheral pulmonary arteries in the present series were not verified histologically Histologic studies have however indicated that the elastic media is primarily involved in this disease entity although chronic inflammatory processes may be found in all of the layers of the arterial wall (TOKORO et coll 1962 NASU 1963) This means that any artery if it has elastic media may be involved

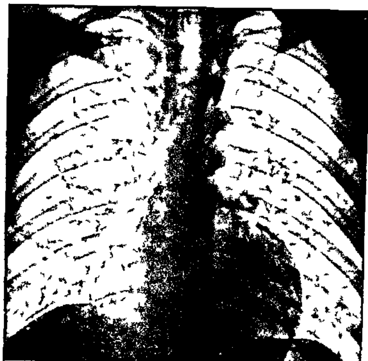
Panarteritis would seem to be a reasonably adequate clinical term for describing extensive whole body distribution of the lesions This term is stated to be pathologically inappropriate however because it means primary involvement of all the layers of the arterial wall while most of the intimal changes are secondary

Various etiologic factors suggestive of the disease include tuberculosis rheumatism and allergy A series of experiments support the hypothesis that it is an auto immunizing condition because an increased titer of the antibody against the blood vessels has been observed in the serum of such patients (H UEDA et coll 1963) This theory seems to be a reasonable one for explaining the wide range of the arterial changes

Although arteriography is necessary for delineating the extent and character of the vascular damage in the aortitis syndrome it is clear that a definitive diagnosis of the condition is also possible from the conventional chest film Apart from direct signs of aortitis evidence of pulmonary vascular changes will contribute materially to the correct diagnosis

SUMMARY

Roentgenologic studies of pulmonary vascular changes in 35 cases of the aortitis syndrome are reviewed The appearances at arteriography are described and the value of the conventional roentgen examination of the chest is stressed



a



b

Fig 3 Man aged 22 a) The descending aorta is irregular in outline narrowing of the segmental and peripheral pulmonary vessels in the upper part of the right lung b) Narrowing of the proximal part of the right pulmonary artery with obstruction *of the right upper lobe artery Narrowing irregular contours* and course of the vessels in other parts of the lung slight dilatation and tortuosity of the left pulmonary artery

FROM THE DEPARTMENT OF PATHOLOGY KAROLINSKA SJUKHUSET STOCKHOLM, SWEDEN

ANASTOMOSES BETWEEN EXTRACARDIAC VESSELS AND CORONARY ARTERIES — III — MICROANGIOGRAPHIC APPEARANCE

by

ANDERS MOBERG

The observation that marked stenosis or even complete occlusion of coronary arteries does not necessarily lead to instant death or widespread myocardial necrosis dates from the late 19th century (HIRSCH & SPALTEHOLZ 1903 HERRICK 1912) The collateral circulation in the human heart especially anastomoses between the major branches of the coronary arteries has since been much studied the work by FULTON (1965) being the latest In extensive and severe coronary atheromatosis however intercoronary anastomoses cannot increase the total amount of blood supplying the myocardium (BLOOR & LIEBOW 1965) An increase in the blood supply to the myocardium in ischaemic heart disease must come either from extracardiac sources with which we are now concerned or from within the heart (endomural anastomoses) and practically nothing is known about the possible collateral function of the endomural vessels (thebesian and arterioluminal) (BLOOR & LIEBOW)

The existence of anastomoses between extracardiac mediastinal vessels and

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ZUSAMMENFASSUNG

Die röntgenologischen Veränderungen in den Pulmonalgefässen wurden an 35 Fällen die das Aortitissyndrom aufwiesen, studiert Die arteriographischen Erscheinungen werden beschrieben und der diagnostische Wert der gewohnlichen Röntgenuntersuchung wird betont

RÉSUMÉ

Les auteurs résument l étude radiologique des modifications des vaisseaux pulmonaires dans 35 cas de syndrome d aortite Ils en décrivent les aspects artériographiques et soulignent l intérêt de l examen radiologique simple du thorax

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The existence of anastomoses between extracardiac mediastinal vessels and

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the coronary arteries has long been known (HALLER 1803, HUDSON, MORITZ & WEARN 1932) but only a few recent publications deal with them (PETERLENZ 1963, 1965). In previous studies of the present series (MOBERG 1967), applying the technique of post mortem contrast injection and radiography, anastomoses have been demonstrated between the bronchial and the coronary arteries in all the subjects examined, newborn infants as well as adults. Anastomoses between the internal mammary and the coronary arteries, however, could be demonstrated in only four out of 19 specimens. Anastomoses between the bronchial and the coronary arteries have been demonstrated radiologically in a few living subjects (ARVIDSSON & MOBERG 1964, 1966).

BJORK (1966 b) in reviewing 200 coronary angiographies in living subjects, was able to identify an anastomotic flow from the bronchial to the coronary arteries in 73 subjects. The anastomoses were demonstrated more often in subjects with coronary atheromatosis, 53 out of 109, than in those, 20 out of 91, with angiographically normal coronary arteries.

The anatomical demonstration of these channels does not prove that they transport significant amounts of blood under normal or pathologic conditions. WEYRAUCH & DEGARIS (1937) found in an experimental study that normal arteries transformed into collateral vessels had constant morphologic changes. The arteries dilate, elongate and twist, and their walls become thicker. BELLMAN et coll. (1959) were able to demonstrate the same changes in precapillary vessels. WESSLER & SCHLESINGER (1953), in an angiographic study of amputated gangrenous legs, reported that many of the anastomotic vessels had a characteristic cork screw shape. The anastomotic pathways developing in conjunction with chronic occlusion of the abdominal aorta also have a similar pattern (CARESANO 1966). BELLMAN & FRANK (1958) demonstrated in the normal heart that the intercoronary anastomoses are straight non branching vessels. BAROLDI et coll. (1956) and JAMES (1961) found that arterial anastomoses in the human heart are of two types: long, narrow and essentially straight vessels or wide and tortuous with a cork screw appearance. It has been stated: 'When anastomoses function for major flow in collateral circulation they become tortuous and elongated, in appearance which is in contrast to their shape in normal hearts' (JAMES 1965).

In an attempt at elucidating by morphologic criteria whether or not the extracardial anastomoses actually have functioned as collaterals, spiralling and widening of the vessels would appear to constitute indicators of collateral adaptation. The purpose of the present part of the study has been to determine the course, whether straight or spiral, of the extracardial anastomoses, and thereby to establish whether these anastomoses had the morphologic criteria of collaterals that had functioned during life.

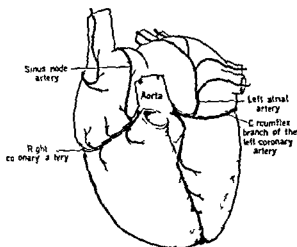


Fig 1 The ventricular and atrial arteries of the heart drawn schematically The sinus node artery as in most hearts (55) arises from the right coronary artery In the present series the three atrial arteries were difficult to distinguish from each other and have therefore been jointly designated as one artery

Anatomy The majority of human beings have no pericardial adhesions The only possibility for blood from extracardiac sources to reach the coronary arteries is therefore (1) to the pericardial reflexion and then (2) either via the vasa vasorum of the aorta or the atrial arteries Previous investigations have demonstrated that the main anastomotic pathway is through the atrial arteries (MOBERG 1967 PETELENZ 1965) The largest atrial artery is the sinus node artery or ramus ostii cavae superioris (JAMES 1961) This artery arises from the first few centimetres of the right (55 per cent) or left circumflex artery (45 per cent) and ascends along the anterior atrial walls to encircle the superior vena cava and supply the sinus node (Fig 1) All other atrial arteries are small and vary in number and location none has a size comparable with that of the sinus node artery All the right and left atrial arteries including the sinus node artery were previously designated as anterior intermediate or posterior depending upon their origin (SPALTEHOLZ 1924) These arteries arise from a ventricular coronary artery arborize over the atrial walls, and reach the pericardial reflexion at the vein terminations

A detailed description of the anatomy of the bronchial and coronary arteries has been given in part I of this series of articles (MOBERG 1967)

Material and Methods

Series of cases The investigation was carried out in autopsy specimens, the interval between death and autopsy ranged from 3 hours to 5 days, during which period the bodies were refrigerated The adult material was collected exclusively for the study

Table 1

Age and percentage of intact lumen of coronary arteries (mean values)

Age (yrs)	Sex and number of cases		Percentage of intact lumen of coronary artery		
	Males (24)	Females (14)	Right	Left descending	Left circumflex
—20	1	1	53	62	52
21—30	1		41	31	36
31—40		1	53	49	65
41—50	3	1	36	20	35
51—60	2	3	37	36	41
61—70	7	3	17	20	18
71—80	8	4	22	18	24
81—90	2	1	19	24	15
	Over all pattern		*27*	*25*	*28*

The degree of stenosis was determined on perpendicular transverse sections of the arteries In atheromatosis the internal elastic lamina was often destroyed or changes were present in the media The external elastic lamina was therefore used as reference this means that the degree of stenosis also includes the cross section area of the media The method thus gave low values i e values apparently expressing higher degrees of stenosis The results differ within the age groups but the overall pattern coincides with previous reports (LOBER 1953 MOBERG 1967)

Table 2

Heart weight and myocardial changes

Weight	Recent infarction	Recent and old infarction	Old infarction	Scattered fibrosis	Myocardium without major changes	Total
—300					9	9
301—399	1	1	1	1	3	7
400—499	1	1	1	1	8	12
500—		1	3	2	4	10
Total	2	3	5	4	24	38

Thirty eight adult specimens were obtained at consecutive, personally performed autopsies These were taken from subjects for which the major autopsy diagnoses were non vascular extrathoracic diseases (17), myocardial infarction (7), cerebral vascular conditions (5), pulmonary embolism (3), renal diseases with renal failure (3) and generalized atheromatosis with heart

failure (3) In addition to the three patients with pulmonary embolism four more patients had small pulmonary emboli One of the patients had fibrous pericardial adhesions and in another patient the pericardium was adherent due to massive melanosarcomatous metastases in the region No noticeable contrast filling of the myocardium via these adhesions was obtained Furthermore one patient had carcinoma of the pancreas and another had a cirrhotic liver

The age distribution and the degree of coronary stenosis as evaluated by the method described below are given in Table 1 For heart weights and myocardial changes see Table 2 (A complete list of case records with all pertinent data can be obtained from the author)

Specimens from six newborn infants were also investigated These specimens were from the same series as the eight described in part I the two not included being the infant with congenital aortic valvular stenosis and the full term infant in which the injection was not successful

Injection procedure The chest organs were carefully removed en bloc and separated from the abdominal organs subdiaphragmatically The ascending aorta was doubly ligated extrapericardially at the aortic arch and in all but two specimens was divided between the two ligatures with a clamp on each stump The proximal and distal parts of the oesophagus the subclavian and carotid arteries and the thoracic aortic intercostal arteries were ligated A catheter was put into the thoracic aorta at the diaphragmatic level and a ligature placed around the aorta and the catheter before injection

During the injection, the specimens were at room temperature All injections were carried out with the pressure retort described by LJUNGQVIST (1963) at a maximum pressure of 120 mm Hg

An aqueous suspension of microcrystalline barium sulphate (Micropaque) was used as contrast medium A medium of low viscosity was chosen with the aim of enabling a total outlining of the vascular tree A 7 5 % barium sulphate suspension was found to be suitable No gelatine or formalin was added

It was not possible to set a strict limit to the amount of contrast medium needed for obtaining an adequate filling Besides leakage from ruptured minor vessels and pleural rifts considerable loss of medium occurred in specimens with autolysis of the oesophagus (cf MOBERG 1967) The injection was terminated when contrast medium had been visible in vessels on the pleural surfaces in most lobes for some 10 minutes usually requiring an injection period of about 45 minutes About 500 ml of the contrast suspension was thus injected in the majority of specimens, but in those with excessive leakage more than a litre of the medium could be used

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81—90	2	1	19	24	15
	Over all pattern		27	25	28

The degree of stenosis was determined on perpendicular transverse sections of the arteries In atheromatosis the internal elastic lamina was often destroyed or changes were present in the media The external elastic lamina was therefore used as reference this means that the degree of stenosis also includes the cross section area of the media The method thus gave low values i e values apparently expressing higher degrees of stenosis The results differ within the age groups but the overall pattern coincides with previous reports (LOBER 1953 MOBERG 1967)

Table 2

Heart weight and myocardial changes

Weight	Recent infarction	Recent and old infarction	Old infarction	Scattered fibrosis	Myocardium without major changes	Total
—300					9	9
301—399	1	1	1	1	3	7
400—499	1	1	1	1	8	12
500—		1	3	2	4	10
Total	2	3	5	4	24	38

Thirty eight adult specimens were obtained at consecutive, personally performed autopsies These were taken from subjects for which the major autopsy diagnoses were non vascular extrathoracic diseases (17), myocardial infarction (7), cerebral vascular conditions (5), pulmonary embolism (3), renal diseases with renal failure (3) and generalized atheromatosis with heart

failure (3) In addition to the three patients with pulmonary embolism four more patients had small pulmonary emboli One of the patients had fibrous pericardial adhesions and in another patient the pericardium was adherent due to massive melanosarcomatous metastases in the region No noticeable contrast filling of the myocardium via these adhesions was obtained Furthermore one patient had carcinoma of the pancreas and another had a cirrhotic liver

The age distribution and the degree of coronary stenosis as evaluated by the method described below are given in Table 1 For heart weights and myocardial changes, see Table 2 (A complete list of case records with all pertinent data can be obtained from the author)

Specimens from six newborn infants were also investigated These specimens were from the same series as the eight described in part I, the two not included being the infant with congenital aortic valvular stenosis and the full term infant in which the injection was not successful

Injection procedure The chest organs were carefully removed en bloc and separated from the abdominal organs subdiaphragmatically The ascending aorta was doubly ligated extrapericardially at the aortic arch and in all but two specimens was divided between the two ligatures with a clamp on each stump The proximal and distal parts of the oesophagus the subclavian and carotid arteries and the thoracic aortic intercostal arteries were ligated A catheter was put into the thoracic aorta at the diaphragmatic level and a ligature placed around the aorta and the catheter before injection

During the injection the specimens were at room temperature All injections were carried out with the pressure retort described by LJUNGQVIST (1963) at a maximum pressure of 120 mm Hg

An aqueous suspension of microcrystalline barium sulphate (Micropaque) was used as contrast medium A medium of low viscosity was chosen with the aim of enabling a total outlining of the vascular tree A 7 5 % barium sulphate suspension was found to be suitable No gelatine or formalin was added

It was not possible to set a strict limit to the amount of contrast medium needed for obtaining an adequate filling Besides leakage from ruptured minor vessels and pleural rifts considerable loss of medium occurred in specimens with autolysis of the oesophagus (cf MOBERG 1967) The injection was terminated when contrast medium had been visible in vessels on the pleural surfaces in most lobes for some 10 minutes usually requiring an injection period of about 45 minutes About 500 ml of the contrast suspension was thus injected in the majority of specimens but in those with excessive leakage more than a litre of the medium could be used

Radiographic procedures. After completion of the injection, roentgenograms of the specimens were obtained at 72 kV and 12 mA, using Gevaert Osray films without intensifying screens and an exposure time from 0.5 to 3.5 sec at a FFD of 1.5 m. An anteroposterior view of the chest organs with the pericardium intact, a lateral of the heart, pericardium and mediastinum with the lungs removed and an anteroposterior view of the isolated heart were obtained. The right and left sides of the heart were then divided along the interventricular septum and roentgenograms were taken of each half separately.

In the adult specimens, the atria were then divided from the ventricles, fixed for 2 to 3 days in 10 % formalin, dehydrated and embedded flat in paraffin in the standard manner. In the newborn infants, the halves of the heart, atrium and ventricle together, were treated in the same way.

Microangiography was performed with a Machlett OEG roentgen tube at 10 kV and 8 mA on Kodak Maximum Resolution plates. FFD 100 cm and exposure time 2 1/2 hours. The paraffin blocks of about 1 cm thickness were placed directly on the photographic plates. The geometry causes a maximum photographic enlargement of about 1 %. Each block was exposed twice to obtain a stereo pair, the blocks being moved from the vertical axis between the exposures to give a viewing angle of 9°.

The stereomicroangiograms were examined in a stereoscopic viewer, Sterant (NIFE), at × 7 linear magnification. All atrial vessels were scrutinized for their pattern of course, whether straight, curved or spiral. Vessels down to a diameter of about 0.05 mm could readily be identified and followed by this method.

The lumen diameter of the largest spiral artery in each heart was measured microscopically in the microangiograms in regions where the vessels seemed to lie parallel to the photographic plate. The optic system was a × 6.3 objective, N.A. 0.16, and a × 8 eye piece with an ocular micrometer that was calibrated against an object micrometer divided at 10 μ intervals. The resolving power, taking into account the resolution of the microangiograms (1 000 lines/mm), is less than 5 μ, but it was found reasonable to work to an accuracy of about 20 μ. No allowance was made for the varying degrees of filling and distension of the vessels. The diameters given for the vessels are thus to be considered as mutually relative and not as absolute in vivo figures.

Method of correlation with atheromatosis. The degree of stenosis of the coronary arteries was determined according to the method devised by LOBER (1953) in order to find out whether a correlation existed between the width of the extracardial anastomoses and the severity of coronary atheromatosis (Table 1). The procedure, described in detail in part I of this series of articles, involved

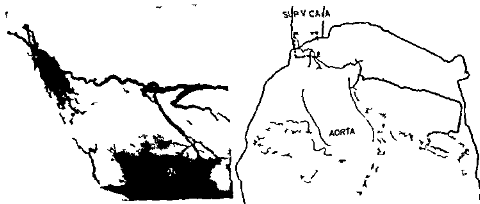


Fig 2 In the roentgenogram one single spinal artery is seen close to the termination of the superior vena cava all the other vessels run a straight course A semischematic drawing has been made from the roentgenograms obtained it shows the area depicted microangiographically

microscopic examination of five blocks from the first five centimetres of each of the three main coronary arteries The cross section area of the lumen is given as a percentage of that of the entire artery The greatest degree of stenosis has been taken as the value for the coronary branch in question

Results

Macroscopic observation One or more of the major coronary arteries, right left descending or left circumflex were filled with contrast medium in all 38 adult specimens In 25 of these, contrast medium was present in the sinuses of Valsalva or the ascending aorta All three coronary arteries were filled in 20 subjects the right and the left circumflex branches in 9, only the right branch in 5 only the left circumflex in 2 and the left descending branch together with the right in one subject or the left circumflex in another subject

Contrast filled vessels in the atrial walls were so numerous in many hearts that it was impossible to determine which of the larger atrial arteries was the major afferent vessel

The parietal pericardium of all 38 subjects contained contrast filled vessels not only posteriorly but often in the anterior and diaphragmatic portions as well

The bronchial arteries to all lobes of the lungs were filled in every specimen Judging from the anteroposterior roentgenogram of the lungs anastomoses between the bronchial and the pulmonary arteries had been present in both

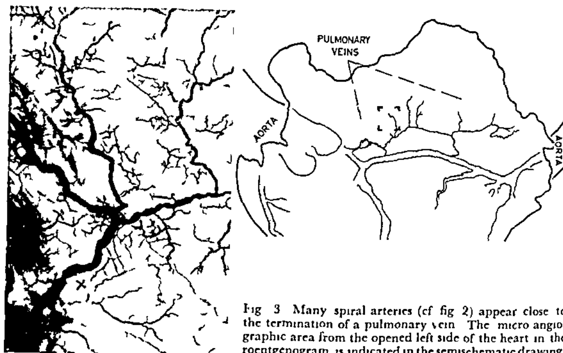


Fig 3 Many spiral arteries (cf fig 2) appear close to the termination of a pulmonary vein The micro angiographic area from the opened left side of the heart in the roentgenogram is indicated in the semischematic drawing

lungs of 35 subjects and in either the right or the left in another two The film of the remaining specimen was underexposed so that a definite decision on this point was impossible

In all the six newborn infants, communications were demonstrated between the bronchial arteries and the coronary arteries at the ventricular level (cf MOBERG 1967)

Microscopic observations Contrast filled vessels were present in every instance in both atrial walls The number of filled vessels varied but in most specimens the majority of the larger arteries in the atrial walls seemed to contain contrast medium There was good agreement between the microangiographic and the microscopic appearances Only slight atheromatosis in the atrial arteries was evident and, in a few specimens, slight patchy fibrosis in the atrial walls

Spiral vessels were easy to recognize, and by following their course it was possible to distinguish intra atrial anastomoses from those to the ventricular coronary arteries Small vessels with a spiral course were nearly always situated close to the ostia of the veins (pulmonary, inferior or superior vena cava) (Fig 2) If the larger arteries in a specimen were spiralled, the smaller ones also followed a spiral course (Fig 3) The diameter of the largest spiral artery with a link to a ventricular coronary artery has been plotted against the age of the subject (Fig 4) Straight vessels were seen in 5 of the newborn infants and

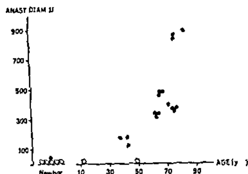


Fig 4 The diameter of the largest spiral artery in each heart has been plotted against the age of the subject The rings indicate specimens in which the arteries followed a straight course

only a single spiral artery was identified in the sixth Straight vessels were also visible in a 11 year old girl and a 49 year-old man These two subjects previously healthy died from intracranial tumours (a craniopharyngeoma and a pituitary chromophobe adenoma respectively) Spiral arteries were observed in the remaining 36 subjects The largest spiral artery had a lumen diameter of 880 μ, this patient was a 83 year old man with a 10 year history of repeated myocardial infarction Spiral arteries with a lumen diameter of more than 500 μ was noted in 8 subjects and seven of them were over 70 years of age A diameter of less than 200 μ was observed in 8 subjects six of these were under 60 years of age The lumen diameter of the largest observed spiral artery thus seemed to increase in a fairly uniform manner with age A nine year old boy who died from leukemia with severe anemia, had fairly wide spiral arteries (330 μ) and thus deviated from the rest of the material

The number of spiral arteries in each heart differed greatly between the specimens but appeared to increase with the age of the subject The number of spiral arteries seemed to be greatest in specimens with severe coronary stenosis and extensive myocardial changes An objective evaluation of this point e g by an anastomosis count of the FULTON (1965) type was not made since a prerequisite for such a count is complete contrast filling of all vessels in each specimen This can hardly be achieved by post mortem injection (BELLMAN 1953)

The lumen diameter of the largest spiral artery in the adult material was correlated with age heart weight and the maximum degree of stenosis of the coronary arteries (conventional correlation analysis and the t test, Table 3) An attempt was also made to distinguish between vessels which anastomosed with the right or the left circumflex branches The diameter of the largest vessel to each of these was compared statistically with the same variables as

above The results followed the same general pattern as in Table 3 but to a lesser degree of significance

Discussion

Contrast medium was identified in the coronary arteries and in the sinuses of Valsalva in 25 of the 38 adult specimens In some of these 25 specimens with good outlining of the coronary arteries, contrast filling was noticed only in one or two of the sinuses of Valsalva without any visible medium in the left ventricle In all but two specimens the ascending aorta had been divided before injection, thus excluding direct contrast filling of the coronary arteries via the aorta Filling via bronchopulmonary anastomoses to the pulmonary veins and then to the left ventricle and the aorta is always a possibility, but the left atria and ventricles did not contain any great amount of the contrast medium This indicates that the medium reached the aorta by retrograde flow in the coronary arteries It may further be observed that in the previous investigation (MOBERG 1967), with smaller amounts of contrast medium, the coronary arteries were filled without concomitant filling of the ascending aorta

The results obtained confirm the results of the previous study anastomoses between the bronchial arteries and the coronary arteries at the ventricular level are present in all subjects The major afferent atrial vessel to the coronary arteries could not be determined in this series, since most of the atrial arteries were filled with contrast medium, the result of using large amounts Identification of the afferent vessels was facilitated in the previous study by the less massive filling of the atrial arteries

Spiral vessels may either occur naturally, e g in the renal pelvis (LJUNGQVIST 1963) or the vasa vasorum of the aorta (CLARKE 1965), or be the result of a pathologic process Previous studies of the normal heart have, however, indicated that the coronary artery branches and the intercoronary anastomoses run a straight course (BELLMAN & FRANK 1958, JAMES 1961) Spiralling of the vessels may be a result of a shortening of the distance between the ends of a vessel by fibrotic contraction This phenomenon has been demonstrated e g by LJUNGQVIST (1963) in the preglomerular arteries of pyelonephritic kidneys In the present study, the main concern was the spiral arteries in the atrial walls structures which only to a slight extent are involved in fibrous and cicatricial contraction The overall arterial pattern was straight in the infants, with increasing spiralling and widening in the older subjects This together with the relationship between age, atheromatosis and vascular stenosis leads to the assumption that the development of spiral arteries in the atrial walls is a sign of collateral vascular response (cf JAMES 1965)

Table 3

Correlation analysis in the adult material (38 subjects) with variables of the largest diameter of spiralled anastomosis in each subject in relation to age heart weight and the degree of stenosis of the coronary arteries

Variable	Correlation coefficient	Significance	
Age	0 65	P < 0 1°	**
Heart weight	0 33	1 < P < 5	
Degree of stenosis			
Right coronary artery	0 41	1 < P < 5	*
Left descending branch	0 51	0 1 < P < 1	*
Left circumflex branch	0 37	1 P < 5°	*
Maximum stenosis irrespective of affected artery	0 52	P < 0 1°	**

Post mortem angiograms do not of course indicate the direction of the blood flow The prerequisites for collateral vascular response are the presence of a pressure gradient and an alternative pathway (HOLMAN 1949) The alternative pathway has been demonstrated There are also morphologic aspects compatible with a pressure gradient The author has earlier found that atheromatosis was less marked in the bronchial than in the coronary arteries (unpublished data) and the diameter of the lumen of the spiral arteries became greater with increasing stenosis of the coronary arteries (cf Table 3) Thus a reasonable conclusion is that blood flowed from the bronchial to the coronary arteries When bronchial coronary anastomoses have been demonstrated in vivo (ARVIDSSON & MOBERG 1964 BJORK 1966 b) the flow has been from the bronchial to the coronary arteries in patients without cardiac anomalies (BJORK 1966 a)

Significant correlations were noted in the adults between the diameter of the largest spiral artery and (1) the maximum degree of coronary stenosis regardless of the artery affected (***) and (2) the degree of stenosis in the left descending artery (**) Correlation between the largest spiral artery diameter and the degree of stenosis in the right and left circumflex branches did not quite reach a significant level (*) Attempts to correlate the diameter of the spiral arteries supplying the right and left circumflex branches and the degree of stenosis in the corresponding coronary branches gave a similar pattern It may be seen from Table 1 that coronary stenosis was most marked in the left descending artery and the left circumflex branch was least affected (cf ACKERMAN et coll 1950 WHITE et coll 1950 LOBER 1953) The results thus suggest that the diameter of the spiral arteries is principally influenced by the over all degree of stenosis in the coronary arteries

The pressure gradient, which is a prerequisite for blood flow through an anastomotic pathway, could be induced on a mere physiologic basis If the pressure pulses in two main systems, bronchial and coronary in this context, are sufficiently out of phase, pressures may at some time in the cycle be so different that the gradient arises Intimation that this phenomenon occurs in the dog with a bronchial to coronary flow has been put forward (VIDONE et coll 1956) The pathologic background for a pressure gradient is stenosis in part of a vascular system Stenosis may not be demonstrable post mortem, kinking of rigid coronary arteries may considerably narrow the lumen, as has been demonstrated in coronary angiographies performed in vivo (NORDENSTROM 1964) In the present consecutive but heterogeneous post mortem series it was not possible to obtain any definite and reliable information concerning the coronary function In the adult series there was closer correlation between the diameter of the largest spiral artery and age than between the spiral artery diameter and the post mortem degree of coronary stenosis Coronary stenosis however, is a variable reflexion of atheromatosis which, in turn, is correlated positively to age (ACKERMAN et coll 1950, WHITE et coll 1950, LOBER 1953) A closer correlation for 'age is therefore not surprising, as in this context 'age in addition to coronary atheromatosis takes other data into consideration and sums up the individuals entire clinical, subclinical and physiologic experiences If, however, one single cause can be put forward as the primary factor in the development of spiral anastomoses it would appear to be coronary atheromatosis

A degree of correlation (*) between the largest diameter of a spiral artery and the heart weight was observed The mean heart weight for this series was fairly high, however, i e 405 g In both normal and hypertrophied adult hearts there is one endomysial capillary for each muscle fibre (ROBERTS & WEARN 1941) It is generally assumed that an increase in fibre size means that vascular supply is correspondingly relatively inadequate The degree of correlation between spiral artery diameter and heart weight most likely reflects the association between the latter and arteriosclerotic processes, fibre size and hypoxydosis of the myocardium

The largest spiral artery had a lumen diameter of 880 μ, the relative rather than absolute significance of the diameter measurements has been previously discussed BJORK (1966 b) found anastomoses with a diameter of 2 mm or more in coronary angiographies in 14 living subjects Since post mortem diameters cannot be directly applied to living subjects, and since it is difficult to measure exactly the diameter of an anastomosis in coronary angiography, the figures cannot be compared and can only serve as an approximate guide Whatever the precise diameter of the extracardial anastomoses, the fair

conclusion from the pattern in Fig 3 — not with one spiral artery but with a vascular bed of spiralled anastomotic vessels — is that at least in some adult hearts the extracardial anastomoses are capable of supplying the coronary circulation with a considerable amount of blood

Acknowledgement

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SUMMARY

Anastomoses between the bronchial and coronary arteries were observed post mortem following the injection of contrast medium and radiography and stereoscopic microangiography in 38 adults and 6 newborn infants Morphologically the spiral form of the anastomoses in 36 of the adults indicated that they were collateral vessels The diameter of the spiral arteries could be correlated to age and degree of coronary stenosis

ZUSAMMENFASSUNG

Anastomosen zwischen den Bronchial und den Koronararterien konnten mittels gewohnlichen Rontgenaufnahmen und Stereo-Mikroangiographie nach Kontrastfullung post mortem bei 38 Erwachsenen und 6 neugeborenen Kindern festgestellt werden Die Spiralform der Anastomosen in 36 von den Erwachsenen deutete darauf hin dass die Gefässe eine kollaterale Funktion hatten Korrelation zwischen den Diametern der spiralformigen Arterien und dem Alter und dem Grade der Koronarstenose konnte festgestellt werden

RÉSUMÉ

Des anatomoses entre les artères bronchiques et les arteres coronaires ont été mises en évidence après la mort par injection de moyen de contraste suivie de radiographie et de micro-angiographie stéréoscopique chez 38 adultes et chez 6 nouveau nés La forme spirale de ces anastomoses chez 36 des adultes montre que ce sont des vaisseaux collatéraux On a pu établir une corrélation entre le diametre de ces artères spirales et l age et le degré de sténose coronarienne

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CIRCULATORY EFFECTS OF IOTHALAMATE COMPOUNDS (CONRAY) AND CONTRAST MEDIA OF THE BENZOIC ACID TYPE

by

P LINDGREN, G F SALTZMAN and G TORNELL

It is obvious that circulatory side effects may occur in connection with roentgen examinations involving parenterally administered contrast media These may be due for example to changes in the elements formed in the blood (erythrocyte aggregation), to an influence on cardiac function, a direct action on the blood vessels, or an effect on the autonomic centers of the nervous system These factors have for a number of years been investigated experimentally by the present authors (LINDGREN & TORNELL 1958, KAGSTROM, LINDGREN & TORNELL 1958, 1960, LINDGREN & SALTZMAN 1962, TORNELL 1963, LINDGREN, LOFSTROM & SALTZMAN 1964)

One of the most consistent observations was the great difference in circulatory reactions between acetrizoate and diatrizoate preparations, the latter being much less pharmacologically active than the former, in spite of the fact that both are tri iodo benzoic acid derivatives This difference has also been reported by numerous other investigators, and a surprisingly good correlation

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between experimental and clinical observations has been established The sodium or methylglucamine salt of iothalamic acid, marketed under the brand name of Conray was selected for the present investigation This substance has the same amount of iodine and molecular weight as sodium diatrizoate in spite of the fact that these are chemically entirely different substances

Most of the investigations published on iothalamate preparations deal with their clinical use and effects The majority of authors report favourable experiences from both intravenous and intraarterial administration and place the compound in the same group as sodium diatrizoate as regards side effects (or perhaps more correctly the absence of such effects) (STEINBERG & EVANS 1962 FOSTER WINFREY KILLEN & SESSIONS 1962 KANICK & FINBY 1963) Critical reports have however also been published serious side effects and even fatalities have been observed by HINCK & DOTTER (1962) and BERNSTEIN RELLER & GRAGE (1962) The latter authors also reported experimental findings Aortography with 2 ml/kg sodium iothalamate caused persistent neurotopic or renal signs in dogs 1 ml/kg intravenously produced only small changes in blood pressure while 2 ml/kg gave a fall and 3 ml/kg even produced marked bradycardia and rhythm changes SESSIONS et coll (1962) investigated the neurologic and renal toxicity and concluded that sodium iothalamate 80 % is less toxic than any of the currently available concentrated angiographic contrast media In another paper by the same group (RHEA et coll 1964) it was stated that sodium iothalamate (Angio-Conray 80 %) was somewhat more toxic than diatrizoate Na/M (Hypaque M 90 %) when injected repeatedly into the aorta in dogs The neurotoxic and nephrotoxic effects were studied However considering the higher iodine content of the former (480 mg/ml against 462 mg/ml) sodium iothalamate appeared preferable Similar results were reached in an experimental investigation by STEWART et coll (1965) who found the spinal cord toxicity of iothalamate Na/M (Angio Conray 80 %) to be higher than that of diatrizoate Na/M (Hypaque M 90 %) Another method of investigating the toxicity of contrast media was used by FUJII et coll (1963) who made histologic studies of resected intestinal segments after intraarterial injections in dogs and reported a diatrizoate compound (Renografin) and a iothalamate compound (Methylglucamine Conray) to be the least damaging to the intestine

The aim of the present investigation was primarily to compare the circulatory effects of sodium iothalamate with those of two well known contrast media sodium diatrizoate and sodium acetrizoate The former was chosen as a reference substance because it is widely used clinically and experimentally Both diatrizoate and acetrizoate preparations have been used by the present authors in their previous investigations on the influence of media on the

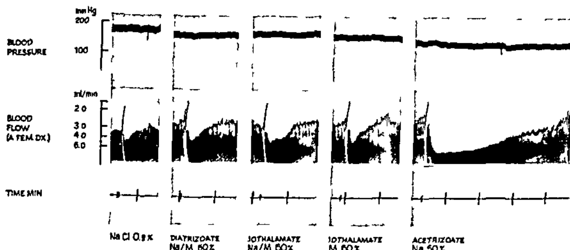


Fig 1 Typical changes in the femoral blood flow after intraarterial injections of 0 05 ml/kg of different contrast media in a cat weighing 3 0 kg

peripheral circulation The aim was also to investigate more in detail how their technique for peripheral blood flow studies could be used as a method for a quantitative assay of the vascular activity (vascular toxicity) of contrast media It was also to be determined whether any similarity existed between the pharmacologic activity of the contrast media, demonstrated in the vasodilator responses following intraarterial injections, and the systemic effects and blood pressure changes when the media were given intravenously

Methods The effects of the contrast media were studied in 37 cats weighing between 2 0 and 4 3 kg, anesthetized with intraperitoneal sodium pentobarbital (30 mg/kg) Supplementary doses were given intravenously, if necessary, during the course of the experiment A tracheal cannula was inserted to facilitate respiration The arterial blood pressure was recorded from the left carotid artery by means of a Statham electromanometer (P 23 AA) connected to a *Grass Model 5 polygraph*

The blood flow in the femoral artery was recorded by a technique described by LINDGREN (1958) The blood was directed from the cannulated central stump of the ligated artery via a plastic tube to a drop chamber of plexiglass and back to the peripheral stump of the artery The plastic tubes and the drop chamber were enclosed in a thermostatically controlled (38° C) water jacket The drops were recorded by a phototube operating an ordinary recorder (GOLDSCHMIDT & LINDGREN 1962) connected to a Grass Polygraph The records, directly proportional to the drop intervals and indirectly proportional to the rate of flow, were calibrated in millilitres per minute (ml/min) Heparin

25 mg/kg was given intravenously in order to prevent clotting. Intravenous injections were made via a thin polythene catheter into a cutaneous vein of the foreleg. Intraarterial injections were given through a thin polythene tube inserted into the outflow cannula from the drop chamber, that is to say the injections were made distally to the drop chamber so that the blood flow recorded was delayed for a few seconds. This fact is illustrated by the initial long interval concomitant with the injections (Fig. 1). This effect is therefore an injection artefact and should not be misinterpreted as due to vasoconstriction. The following contrast media were used in the present investigation.

		Concentration in per cent	Iodine content mg/ml
Acetrizoate Na	(Rheopak)	50	328
Diatrizoate Na	(Hypaque)	50	300
Diatrizoate Na/M	(Urografin)	60	290
		76	370
Iothalamate Na	(Conray)	40	240
		50	300
		60	360
		70	420
		80	480
Iothalamate M	(Conray)	60	282
Iothalamate Na/M	(Conray)	60	290
		76	370

Na = sodium salt. M = methylglucamine salt. Na/M = mixture of sodium and methylglucamine salts in the proportion 10:66.

Results

Intraarterial injections of sodium diatrizoate, iothalamate and acetrizoate preparations (femoral arteriography). A first series of eight experiments were carried out in which sodium diatrizoate (Urografin) and sodium acetrizoate (Rheopak) were injected for comparison in order to obtain an orientation on the vascular activity of sodium iothalamate. The results in one of the experiments are recorded in Fig. 1; the doses were small, i.e. 0.05 ml/kg, corresponding to a dose of 3 ml in human subjects. The vasodilator reactions caused by the two iothalamate preparations were similar to those of the diatrizoate substances, whereas the acetrizoate compounds had a much stronger vasodilator effect. It is true that there were large differences in sensitivity between the individual cats, but the ratio between the responses caused by the various contrast media did not change much, a fact that may justify comparing the mean values from the data of the eight experiments given in the diagram of Fig. 2. The values are

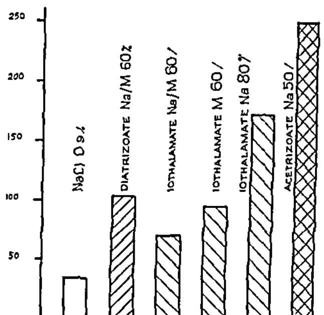


Fig 2 Increase in femoral blood flow in per cent of the resting level after intraarterial injections of 0.05 ml/kg of different contrast media Means of 8 experiments

expressed as increase in the blood flow, expressed in per cent of the resting level This means for example that if in two experiments the resting femoral blood flow was 4 ml/min and 6 ml/min, respectively, and increased to 6 and 9 ml/min, respectively, at the height of the vasodilator response, the response in both instances is expressed as a 50 % increase A particular advantage of the percentage calculations is that blood flow differences due to different body weights are neutralized The diagram indicates that no differences worth mentioning existed between the diatrizoate Na/M and the iothalamate Na/M responses, and that the iothalamate M effect also differed very little The two former preparations have the same iodine content and the same proportions of sodium and methylglucamine salts, whereas the iothalamate M has less iodine The latter compound was included because it is used clinically, the same applies to the sodium iothalamate 80 %

The method of taking only the magnitude of the responses into consideration may provide good information on the vascular activity of the compounds tested, when threshold doses are used, in other words if only partial relaxation is obtained But when larger doses or more active compounds are used, a reaction consisting of a maximal or almost maximal vasodilatation may occur A comparison only of the flow increase at the very instant it is at its maximum may thus produce a false picture of the vascular activity of the two compounds A comparison of the effects of sodium iothalamate 80 % and sodium acetrizoate 50 %, in doses of 0.05 ml/kg, can be made in Fig 3 The former gave a

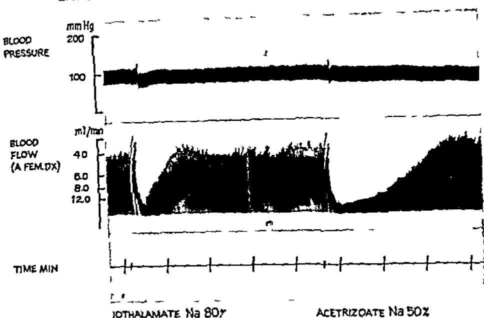


Fig 3 Increase in femoral blood flow after intraarterial injection of 0 05 ml kg of iothalamate Na 80 and acetrizoate Na 50 in a cat weighing 3 7 kg

flow increase of 305 % and the latter one of 350 % These figures might suggest that the two compounds have about the same vascular effect However the records indicate that the reactions are different, the sodium acetrizoate reaction being of much longer duration It was not the object of the present investigation to determine whether the cause of this longer duration was due to e g higher affinity of the drug to the effector cells or to some other property There is no doubt however that the vascular reaction will be better presented if both the intensity of the reaction and its duration are taken into the consideration In order to simplify the evaluation of the response the product of the parameters is given instead of listing both parameters separately

Biologically the meaning of this product is easiest to explain if the increase in flow is expressed as absolute units ml/min (the difference maximum flow minus resting flow) Thus the product

$\frac{\text{flow increase in ml/min}}{2} \times$ duration in minutes would mean the amount of blood passing through the vessel (and the tissue) in addition to that which should have passed under resting conditions provided the return of the blood flow to its resting level can be regarded as linear In other words if the blood

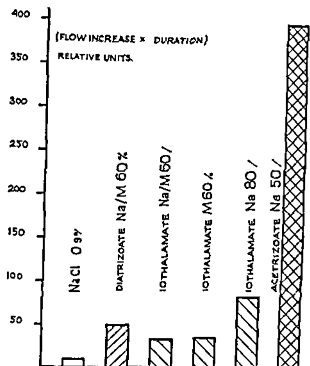


Fig 4 Vascular responses to intraarterial injections into the femoral artery of 0 05 ml/kg of different contrast media Means of 8 experiments

flow response can be regarded as triangular in shape, the product, i e the surface of the triangle, means the increased amount of blood that has flowed This amount of blood can be regarded as a fair indication of the vascular reaction, i e the vasodilation and decreased peripheral resistance This approximation to a triangle of the recorded responses has been made in this study For reasons mentioned above the increase in blood flow is expressed as a percentage of the resting level rather than in absolute values These percentage values have also been used in the calculation of the products, i e the products are expressed in relative values This fact, however, constitutes no disadvantage in the present study because the object has been only to compare the vascular activity of different compounds, not to give absolute values for the responses

Calculating the responses shown in Fig 3 as products according to the principle mentioned, the figures of 140 and 470, respectively, for iothalamate Na 80 % and acetrizoate Na 50 % are obtained The magnitude of the vascular reactions and the difference between the vascular activity of the two compounds are thus better reflected

A diagram, in which the vascular reactions are expressed as products (flow increase times duration), is given in Fig 4, the experimental material was the same as in Fig 2 The most striking change from Fig 2 is however the accentuated difference between on one hand the group formed by the

Table

Comparison of the vascular activity on injections into the femoral artery of diatrizoate and iothalamate compounds in four different series of experiments — Mean values in relative units based on the products of the flow increase times the duration divided by 2 — Activity of diatrizoate (in each series) = 100

Injected amount ml/kg	Number of experiments	Number of injections	Contrast medium	Vascular activity
0 1	3	34	Diatrizoate Na/M 60	100
		17	Iothalamate Na 50	112
0 05	4	24	Diatrizoate Na/M 76	100
		24	Iothalamate Na 60	79
0 05	4	15	Diatrizoate Na 50	100
		15	Iothalamate Na 50°	116
0 2	4	15	Diatrizoate Na 50	100
		15	Iothalamate Na 50	103

diatrizoate and iothalamate compounds and on the other hand the acetrizoate preparation

It was observed in several experiments that an injection (same dose and same substance and concentration) given early in the experiment did not produce a similar response when administered one or two hours later The later responses expressed both as flow increase and as product were usually larger One reason could be a fall in the blood pressure level and a lower resting blood flow level An increase in the vasoconstrictor tone may also be considered Care was therefore taken not to give too many injections in one experiment or to continue too long with the experiment In the experimental series presented above the diatrizoate Na/M and the iothalamate Na/M injections were administered with only a few minutes interval In some experiments the former substance was injected prior to the latter and in others vice versa It is therefore unlikely that the time factor could have influenced the results However in order to eliminate this factor other series with alternate injections of only two compounds were performed The results of four such series are presented in a Table The means of the diatrizoate responses were given the value 100 in relative units in order to make the comparison easier The primary data underwent statistical analysis but in no instance could any significant difference between the responses caused by the iothalamate and diatrizoate substances be established

Dose response relationship intraarterial injections of iothalamate Na The dose response relationship was studied for various concentrations of sodium iothal

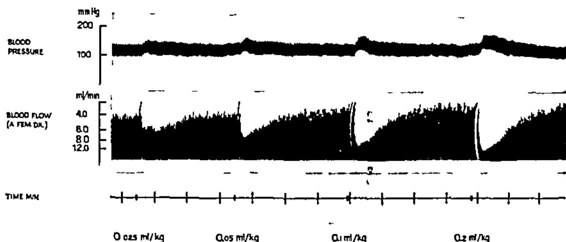
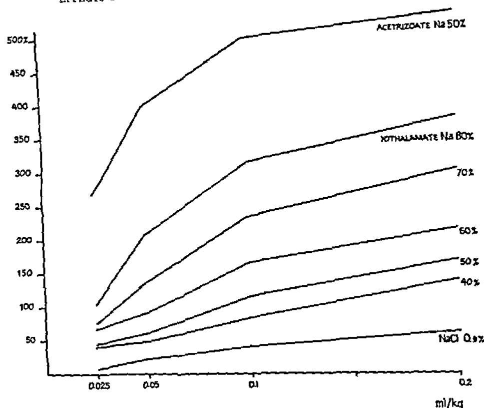


Fig. 5. Typical changes in femoral blood flow after intraarterial injections of increasing doses of iothalamate Na 70 % in a cat weighing 2.0 kg

amate. The reason for choosing the sodium salt was the possibility of including the higher concentrations in the study, particularly the 80 % solution which is used clinically. In order not to load the animal with more contrast medium than necessary, early in the experiment, the lower concentrations were injected first, and then iothalamate 80 % and acetrizoate 50 %. Sodium acetrizoate, the marked vasodilator properties of which were reported by the present authors several years ago, was used as a reference preparation in order to obtain information on the maximal relaxing capacity of the vessels.

Part of an experiment in this series is illustrated in Fig. 5. The doses were 0.025, 0.05, 0.1 and 0.2 ml/kg. It is true that it could have been of some interest even to study the effects of somewhat higher doses, e.g. 0.4 ml/kg, corresponding to a large clinical dose in a human subject; this was not done, however, because it meant that the total amount of contrast medium given would have been increased by more than 100 %. The mean values from eight experiments were used for producing the diagrams in Figs. 6 and 7. These indicate the response as flow increase and the product of the flow increase times the duration, respectively. For the smaller doses the responses were quite moderate, and even for the higher doses of the high concentrations the responses were clearly below the upper limit expressed as the acetrizoate response.

Intravenous injections. The media were injected into the cannulated brachial vein. The arterial blood pressure was recorded in all the experiments, and the peripheral blood flow in a few of them. However, the results now reported deal only with the blood pressure responses. The peripheral blood flow is influenced



F g 6 D se esponse curves for d fferent conc ntrations of iothalamate Na The curves llustrate the increase n femo al blood flow in per cent of the resting level after intraarter al injecti ons and a e b sed on th mean values of 8 exper ments

by so many factors of unpredictable importance, such as blood pressure changes reflex adjustments direct influence of the drug that alterations in the peripheral blood flow can hardly form a basis for quantitative studies as was the case with the intraarterial injections

In Figs 8 and 9 the mean values from four experiments are given in diagram matic form As to the intraarterial responses very little difference was evident between the diatrizoate and the iothalamate compounds and with respect to the fall in blood pressure both gave quite moderate values the fall produced by the acetrizoate preparations was however more marked

The dose response study for sodium iothalamate was limited to the 40 % 60 % and 80 % solutions in order to limit the total amount of contrast medium administered For doses up to 0 67 ml/kg the blood pressure responses were

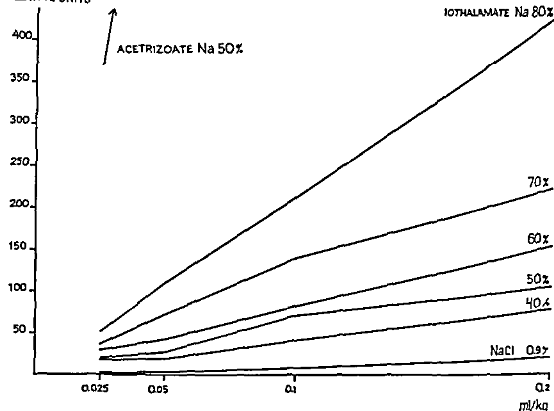


Fig 7 Dose response curves for different concentrations of iothalamate Na The curves illustrate the vascular reaction expressed as the product of the flow increase times the duration and are based on the mean values of 8 experiments *(The values obtained for acetrizoate were 0 025 — 372 0 05 — 820 0 1 — 1348 and 0 2 ml/kg — 1837 units)*

very small (0 67 ml/kg corresponds to about 40 ml in a human subject), and not until 1 33 ml/kg had been given could any difference between the lower and the higher concentrations be demonstrated The intravenous dose response curves that were obtained are indicated in Figs 10 and 11, in mean values of ten experiments In analogy with the interpretation and presentation of the intraarterial responses, the blood pressure responses in Fig 11 have also been expressed as the product of

$$\frac{\text{blood pressure fall in per cent of resting level}}{2} \times \text{duration in minutes}$$

The biologic significance of this product is not as simple as in the former case but the authors feel that it is a more accurate way of presenting the circulatory effects of contrast media than by measuring only the fall in blood pressure

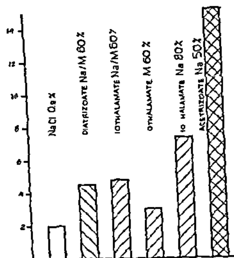


Fig 8 Decrease in mean blood pressure in per cent of the resting level after intravenous injections of 0.5 ml/kg of different contrast media Means of 4 experiments

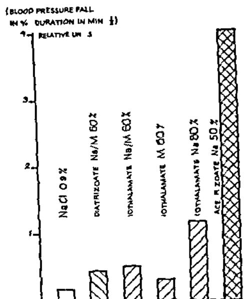


Fig 9 Blood pressure responses expressed as the product of the mean blood pressure times the duration after intravenous injections of 0.5 ml/kg of different contrast media Means of 4 experiments

Discussion

Studies of the effects of intraarterial injections of contrast media of the limb blood flow proved to be a sensitive method of determining the vascular activity of an agent This confirmed the conclusions from previous investigations The doses of 0.025 to 0.2 ml/kg are much less than those needed for studying the effects of intravenous doses on the blood pressure This means that a greater number of injections can be given in one experiment without reaching a too high concentration in the animal The intraarterial doses in the present investigation were also very low compared with the doses often used in testing the media for neurologic reactions i e 1 to 2 ml/kg into the aorta or 2 to 7 ml/kg intravenously (SESSIONS et coll 1962) BERNSTEIN et coll (1962) gave 1 to 3 ml/kg intravenously in investigating the blood pressure lowering effect of the drugs

Good correlation was obtained between the results of the intraarterial and intravenous injections Those preparations that produced a marked increase in blood flow on intraarterial injection gave also a blood pressure fall when injected intravenously This is of course not a surprising observation — a main

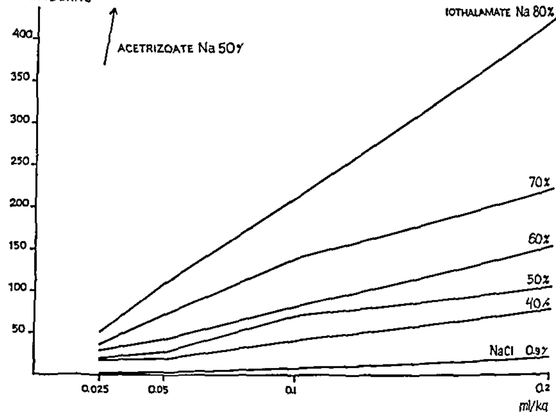


Fig 7 Dose response curves for different concentrations of iothalamate Na The curves illustrate the vascular reaction expressed as the product of the flow increase times the duration and are based on the mean values of 8 experiments *(The values obtained for acetrizoate were 0 025 — 3[illegible] 0 05 — 8[illegible]0 0 1 — 1348 and 0 2 ml/kg — 1837 units)*

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The biologic significance of this product is not as simple as in the former case but the authors feel that it is a more accurate way of presenting the circulatory effects of contrast media than by measuring only the fall in blood pressure

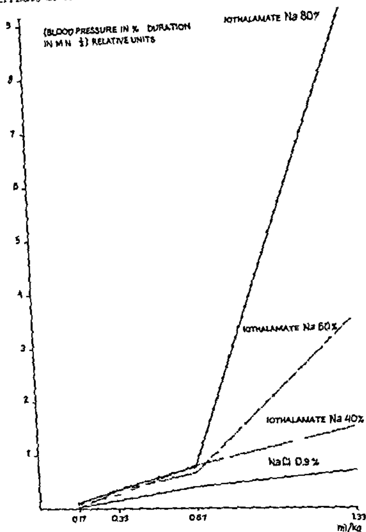


Fig. 11 Dose response curves for different concentrations of iothalamate Na. The curves illustrate the blood pressure response expressed as the product of the blood pressure fall times the duration after intravenous injection. Means of 10 experiments

seems nowadays to be general agreement in the literature (e g TINDALL et coll 1965 HILAL 1966) Most authors also agree that the newer preparations of the diatrizoate metrizoate and iothalamate salts are much weaker vasodilators than the acetrizoate preparations

The possible difference between the effects of sodium and methylglucamine

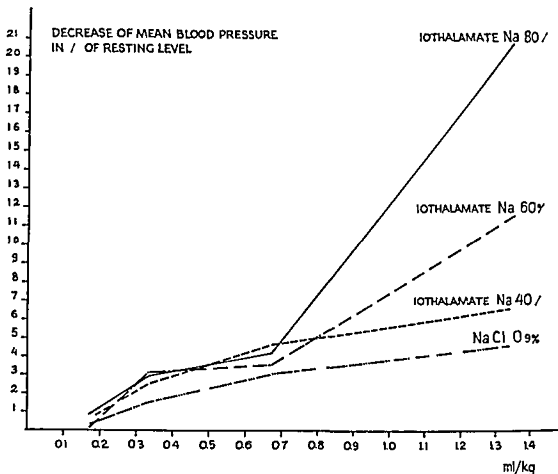


Fig 10 Dose response curves for different concentrations of iothalamate Na Means of 10 experiments

factor lying behind the fall of blood pressure following intravenous injections is probably the decreased peripheral resistance occurring when a not too diluted contrast solution reaches the periphery

As regards the main object of the investigation, namely to compare the circulatory effects of iothalamate substances with the media previously investigated, the principle conclusions seem to be as follows

1 No significant difference was found in the vascular activity between corresponding concentrations of iothalamate and diatrizoate substances Both have a low 'vascular toxicity

2 The marked vasodilator effects after injections of acetrizoate compounds were confirmed, they were considerably larger and more sustained than those of the diatrizoate and iothalamate preparations

As regards the vasodilator properties of practically all contrast media there

Acknowledgements

This investigation was supported by the Swedish Medical Research Council grant No B67 14x 2077 01 and by Astra Sodertalje Sweden who also put the various types of iothalamate compositions at the disposal of the authors The statistical calculations were made by Erik Leander Lecturer at the Department of Statistics University of Stockholm

SUMMARY

The circulatory effects of preparations of the contrast medium iothalamate (Conray) have been investigated in cat experiments and compared with those of diatrizoate (Urografin and Hypaque) and acetrizoate (Rheopak) media The responses were small to moderate for the lower concentrations No significant difference was noted between iothalamate and diatrizoate but the vascular toxicity of the iothalamate was much lower than that of the acetrizoate preparations The clinical implications are briefly discussed

ZUSAMMENFASSUNG

Der Einfluss der Iothalamatlosungen (Conray) auf den Kreislauf wurde an Katzen experimentell studiert und mit Losungen von Diatrizoat (Urografin Hypaque) und Acetrizoat (Rheopak) verglichen Fur schwache Losungen war der Einfluss klein bis massig Keine signifikante Differenz zwischen Iothalamat und Diatrizoat konnte festgestellt werden es erwies sich aber dass Iothalamat geringere Toxicitat aufwies als die Acetrizoatpraparate Die klinische Bedeutung dieser Versuche wird in Kurze besprochen

RESUMÉ

Les auteurs ont étudié par des expériences sur des chats les effets circulatoires de preparations d iothalamate (Conray) et les ont comparés a ceux de préparations de diatrizoate (Urografin) et d acétrizoate (Rheopak) Les réactions sont faibles ou modérees pour les faibles concentrations Aucune différence significative entre les préparations de diatrizoate et d acétrizoate était notée mais la toxicité vasculaire de l iothalamate est tres inferieure à celle des préparations d acétrizoate Les auteurs examinent brievement les implications cliniques de ces résultats

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or mixed salts of iothalamate, was not specifically studied Even if the character of the acid rest is probably responsible for major differencies between the pharmacologic effects of various contrast media, the importance of the positive ion should not be neglected This was the reason for having a special compound, iothalamate Na/M 60 %, prepared for the present study so that the salt composition should be the same as for the reference substance, diatrizoate Na/M 60 %, the latter being identical with the well known Urografin As regards the positive ion, the idea has been expressed in the literature that a methylglucamine salt is less toxic than a corresponding sodium salt FISCHER & CORNELL (1965), in an excellent experimental study, demonstrated that in cerebral angiography the methylglucamine salts of diatrizoate, iothalamate and metrizoate are 'definitely better tolerated than the sodium compounds Similar results have also been obtained for the vascular toxicity, tested by our method, of the highly active acetrizoate preparations, the sodium compounds giving more marked and long lasting vasodilation than the methylglucamine salts (VAN DE BERG 1962 and TORNELL 1963) However, even methylglucamine acetrizoate has a vascular toxicity that is much higher than any diatrizoate compound These facts should therefore be kept in mind when comparing the side effects of e g the two commercial preparations methylglucamine iothalamate 60 % (Conray) and sodium diatrizoate 50 % (Hypaque) LIN et coll (1965) reported that the postangiographic blood pressure depression was milder and of shorter duration with methylglucamine iothalamate 60 % It is, however, difficult to know whether this difference should be regarded as one between a iothalamate and a diatrizoate compound or between a methylglucamine and a sodium salt

The present experimental results agree with the clinical findings that in terms of side effects only minor or no differences between iothalamate and diatrizoate compounds exist, provided comparisons are made between the same concentrations and salt compositions

Almost all serious complications in roentgen examinations in human subjects with iothalamate have occurred with the Angio Conray (80 %) preparation (BERNSTEIN et coll 1962, STEINBERG & EVANS 1962) This is an extremely concentrated solution with an iodine content of 480 mg/ml, it is an open question whether it generally answers a need The most marked reactions in the present investigation were caused by this concentration, as seen in both the intraarterial and intravenous dose response curves As has been suggested previously (LINDGREN & TORNELL 1958), the same amount of substance given in a concentrated solution usually causes a more intense vascular reaction than when dilute This problem has been the object of a separate investigation (LINDGREN, SALTZMAN & TORNELL 1968)

FROM THE DEPARTMENT OF PATHOLOGY (DIRECTOR PROF S RAMSTROM) DEPARTMENT OF SURGERY I (DIRECTOR PROF L E GELIN) AND ROENTGEN DEPARTMENT II (DIRECTOR DOCENT I WICKBOM) SAHLGRENSKA SJUKHUSET, GOTHENBURG SWEDEN

ANGIOGRAPHIC, MICROANGIOGRAPHIC AND HISTOLOGIC STUDY OF VASCULAR MALFORMATION IN STRIATED MUSCLE

by

L ANGERVALL L NILSSON B STENER and I WICKBOM

This communication describes a vascular malformation in striated muscle with angiographic findings of interest in the roentgenologic differential diagnosis of soft tissue tumours A correlated microangiographic and histologic study of the operation specimen helped to interpret the clinical angiograms

Case report

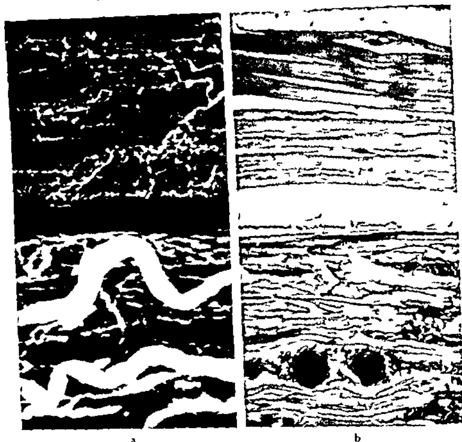
A woman aged 41 had for about 10 years noticed a lump medially in the lower part of the right thigh it had not increased noticeably in size and had not caused any disability No history of trauma

The clinical examination disclosed in the distal part of the vastus medialis a non tender soft elastic ovoid mass with a maximum diameter of about 8 cm and mobile except when the quadriceps was contracted The overlying skin appeared normal

Ordinary roentgenograms with a soft tissue technique failed to distinguish the mass from

Submitted for publication 9 June 1966

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a b

Fig. 2. a) Microangiogram of a 500 μ thick section representing the boundary between ordinary muscle tissue (top) and lesion (bottom) × 35. b) Histologic section at the boundary between ordinary muscle tissue (top) and lesion (bottom). Weigert van Gieson 35.

Microangiographic and histologic study of the operation specimen. As soon as the tumour had been excised the specimen was prepared for microangiographic and histologic study. (For a detailed description of the method see ANGERVALL, NILSSON & STENER 1964.) A mixture of barium sulfate suspension and formaldehyde was infused into the main feeding artery, the descending genicular, and the specimen was then cut into slices about 4 mm thick. The slices were examined macroscopically and a roentgenogram was taken of each (survey angiograms). Thin paraffin sections were made for microangiographic and histologic examination.

Macroscopic inspection revealed numerous large vessels, filled with contrast

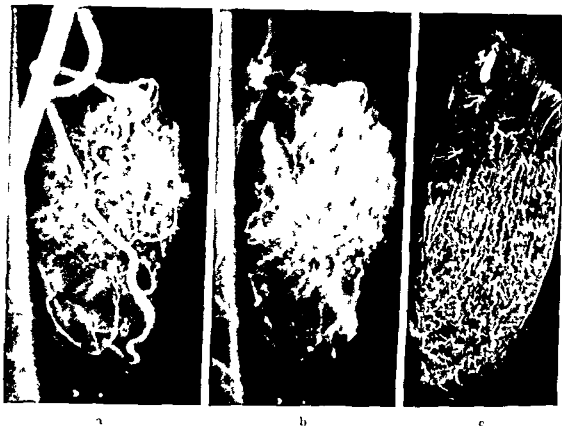


Fig. 1. a) and b) Lemoral angiography. Highly vascular region corresponding to the site of pal pable mass in vastus medialis. The striated appearance (from top right to bottom left) should be noted. *The veins in (b) are filled while there is still contrast medium in the superficial femoral and descending genicular arteries.* c) Survey angiogram of a 4 mm thick slice of the operation specimen. The upper third of the slice has been cut through ordinary muscle tissue, the lower two thirds through the lesion.

the surrounding tissue but it was clearly outlined at femoral angiography by reason of its high vascularity (Fig. 1 a and b). From the markedly widened main feeding artery (descending genicular) the contrast medium passed into an abundance of tortuous vessels and also produced diffuse staining. Wide draining veins were filled while there was still medium in the arteries indicating arteriovenous shunting (Fig. 1b). The highly vascular region presented a certain striation, the significance of which was not clear. In view of the angiographic appearances and the history of no appreciable progression over ten years an angioma was considered likely although the remote possibility of a malignant tumour was borne in mind.

At operation the descending genicular artery was divided and ligated near its origin. The tumour was then excised in toto together with a margin of healthy muscle tissue. Since the lesion was probably benign total muscle excision was not indicated.

The postoperative course was uneventful. At follow up 2 years and 5 months after the operation the patient had no signs of recurrence. She had sustained no significant loss of function.



Fig 3 F vessel w thin the les on (m ddle v ew) clearly d ff r ig f om capillary n ordinary mu cle t ssue o tside the les on (top v ew) Weigert an(eson × 1?10 Bottom view Aff ent and eff rent larg vessels within the lesion the fo n er (←–) *densely filled* w th contrast ned um th latter (←→) only pa tly fill d Lam na el st ca nterna is s en n the affe e t ves ls Weigert ela t n tain ng × 120

medium, at the site of the lesion Muscle fibre bundles passed right through the specimen, unbroken at the boundary between the lesion and ordinary muscle tissue The muscle fibre bundles were distinctly paler within the lesion than outside it (white medium in the vessels)

Fig 1c is a survey angiogram of 1 4 mm thick slice of the specimen The descending genicular artery, used for infusion of the medium, lies at the top The upper third of the slice has been cut through ordinary muscle tissue and the lower two thirds through the lesion Numerous vessels of various calibres, most of them presenting a tortuous course, are evident within the lesion In addition, there is a dense background opacity broken by dark (more radiolucent), parallel streaks These streaks run in the same direction as the muscle fibre bundles seen macroscopically on the cut surface on the slice, many of the vessels, both within and outside the lesion, also have this direction

Fig 2a is a microangiogram of a 500 μ thick section representing the boundary between ordinary muscle tissue (top) and the lesion (bottom), the magnification is $\times$ 35 The microangiograms disclosed that the background opacity in the survey angiograms was caused by numerous fine vessels In general, these vessels had a straighter course and a wider lumen than the capillaries in the surrounding intact muscle tissue (cf top and bottom in Fig 2a)

Histologic examination revealed that bundles of well preserved muscle fibres passed through the lesion between pathologic vessels (Fig 2b) The largest of these vessels were of two different kinds (Fig 3, bottom view) (1) vessels densely filled with contrast medium and whose walls had a more or less distinct lamina elastica interna inside a layer of smooth muscle — apparently afferent vessels, and (2) vessels only partly filled with medium and whose walls contained smooth muscle cells interspersed with elastic fibrils as in veins — apparently efferent vessels The finest vessels within the lesion (Fig 3, middle view), most of which ran parallel with the muscle fibres, were filled with contrast medium and generally had walls that clearly differed from those of ordinary muscle capillaries outside the lesion (Fig 3, top view) they were thicker and contained smooth muscle and elastic fibrils

Discussion

The angiographic and histologic study disclosed that the mass in the vastus medialis was due to various types of differentiated, hyperplastic blood vessels The regular arrangement of these vessels between well preserved muscle fibre bundles indicates a vascular malformation (hamartoma) rather than a true hemangioma

COCKSHOTT W P and EVANS K T The place of soft tissue arteriography Brit J Radiol 37 (1964) 367
LAGERGREN C LINDBOM Å and SODERBERG G Hypervascularization in chronic inflammation demonstrated by angiography Acta radiol 49 (1958) 441
MARGULIS A R and MURPHY T O Arteriography in neoplasms of extremities Amer J Roentgenol 80 (1958) 330
ROSCH H Angiographie und periphere Durchblutung bei Extremitatentumoren ein Beitrag zur Tumordiagnostik Arch klin Chir 305 (1964) 320
STENER B and WICKBOM I Angiography in three cases of muscle rupture with organizing haematoma Acta radiol Diagnosis 4 (1966) 169
SUTTON D Arteriography Livingstone Ltd Edinburgh and London 1962

It is generally held, in clinical angiography of soft tissue tumours, that high vascularity is suggestive of malignancy (SUTTON 1962, ROSCH 1964). An exception is naturally hemangiomas (cf. BARTLEY & WICKBOM 1959); another highly vascular benign tumour is the hibernoma, a special type of lipoma (ANGERVALL, NILSSON & STENER 1964). Certain non-neoplastic lesions may also sometimes appear highly vascular angiographically, such as inflammatory lesions (LAGERGREN, LINDBOM & SÖDERBERG 1958, MARGULIS & MURPHY 1958, SUTTON 1962, COCKSHOTT & EVANS 1964), and muscle rupture with organizing hematoma (STENER & WICKBOM 1966).

In the present case, clinical angiography indicated that the lesion was highly vascular, but it was also noticed that the vascular region had a striated appearance. The correlated microangiographic and histologic study of the operation specimen disclosed that this striation was due to the presence of muscle fibre bundles between the pathologic vessels. It is felt that such striation in the angiographic appearances of a highly vascular mass in a muscle per se may be of diagnostic value, suggesting that the lesion is benign in spite of its high vascularity: a malignant tumour would hardly leave the muscle bundles intact to such an extent as indicated by the angiographic appearance.

SUMMARY

A massive vascular malformation in striated muscle is described. The clinical angiographic findings were correlated with the microangiographic and histologic investigations of the operation specimen.

ZUSAMMENFASSUNG

Es wird über eine massive Gefässmissbildung im quergestreiften Muskel berichtet. Die klinischen und angiographischen Befunde werden mit den mikro-angiographischen und histologischen Befunden am Resektionspräparat in Beziehung gesetzt.

RÉSUMÉ

Description d'une malformation vasculaire massive dans le muscle strié. Les signes angiographiques cliniques sont confrontés avec les examens micro-angiographiques et histologiques de la pièce opératoire.

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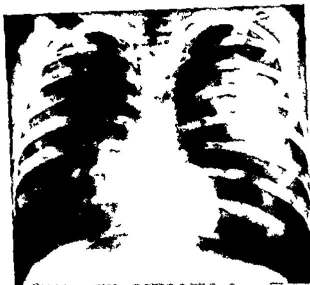


Fig 1 Part al collapse of the left lung w th large pneumothorax extensive infilt at on w th atelecta is of the upper lobe Moder at d placement of the med astinum a d heart to the right

accidents According to STREET & STULL (1958) rupture of the main bronchi is fairly common but the patients usually die of other serious injuries

Partly as a result of the increased number of cases with traumatic bronchial rupture but mainly because of improved modern hospital treatment and care of severely injured patients a pre mortem clinical diagnosis has often been made in recent years Both clinical and roentgenologic experience with this disorder have thus been gained and lives saved although the majority of the patients have had to accept the loss of one lung

The symptom complex in the acute phase may range from almost total lack of symptoms to an extremely precarious general state the reason for this in cases of isolated bronchial rupture being the difference in the position and extent of the rupture The patient is usually in a poor condition on admission to hospital This may be due to fractures of bones and other injuries but may also be caused by bronchial rupture with pneumothorax hemothorax bronchial bleeding and shock The patient frequently has considerable air hunger dyspnea and cyanosis Extensive subcutaneous emphysema usually exists but may occasionally be abs nt Some patients are asymptomatic and without signs on admission but develop changes during the first hours of observation

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TRAUMATIC BRONCHIAL RUPTURE

Acute stage diagnosed by bronchography

by

MATS HAVERLING

Bronchial rupture following thoracic trauma probably occurs through a shearing force acting between the firmly anchored mediastinal bronchi and the more mobile peripheral pulmonary bronchi In the earliest cases of bronchial rupture injury to the thorax was occasioned by falling from horses or from heights, but in recent years traffic accidents have been the more common causes

Bronchial rupture usually occurs in one of the main bronchi close to the carina with the same frequency on either side (NORLIN 1955) Less frequently lobar or segmental bronchi may be torn The first described bronchial rupture was detected at autopsy by Barford Until 1945, the ruptures has usually been discovered after death

Thirty cases had been reported up to 1948 but by 1955 the total figure had risen to 50 (NORLIN) nineteen of these died within 96 hours of the accident A perusal of the recent literature indicates that the number of cases reported amounts to over 167 (BURKE 1962 and OZONOFF 1964) The incidence has increased in recent years due mainly to heavier road traffic and the high rate of

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Fig 3 a Postoperative bronchograms of same patient as in figs 1 and 2 Normal appearances of the left lower lobe bronchi

Case report

A 6-year-old boy admitted after he had been knocked down by a car was conscious but in a state of shock The preliminary clinical and roentgenologic examinations revealed a hematoma of the forehead and fractures of the left radius ulna and ilium The child complained of pain on the left side

Roentgen examination of the abdomen and chest disclosed marked gastric dilatation a left sided pneumothorax and infiltration with atelectasis of the apical segment of the left lower lobe the infiltration was considered to represent a laceration of the lung A second examination of the chest an hour later indicated that there was an increase in the amount of air in the left pleural space and displacement of the mediastinum to the right (Fig 1) Blood in the trachea was present on endoscopy A drainage tube was inserted into the left chest and approximately 200 ml of pure blood and a large volume of air were aspirated the tube was then connected to a suction apparatus Initial improvement was followed by rapid deterioration in the patient's condition Another roentgen examination of the chest shortly after the insertion of the drainage tube into the pleura revealed that the amount of air had increased further despite continuous suction

As the amount of air in the left pleura was increasing despite drainage with continuous section the question arose as to whether bronchial rupture was also present Bronchography as an emergency procedure was suggested to establish a definitive diagnosis and if possible locate the position of the rupture A grey Ödman Ledin catheter with a 45 distal curve was introduced under general anaesthesia into the left main bronchus via the cannula placed in the tracheostomy About 5 ml of contrast medium (aqueous Dionosil) were injected under fluoroscopic control its even distribution to the bronchi being obtained by use of an anaesthetic

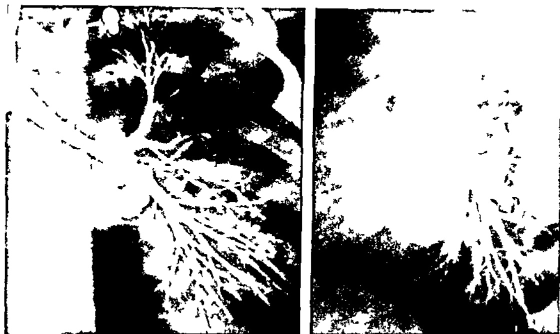


Fig 2 a) Bronchograms of same patient as in fig 1 No filling of the apical bronchus of the lower lobe accumulation of medium in the adjacent tissue

Pathologic features Bronchial ruptures vary from small rifts to complete separation of the bronchial fragments, with consequent total disconnection of the distal airway The extent of the vascular injury and degree of bleeding are not always determined by the size of the rupture or displacement of the two parts of the bronchus A minor tear of the bronchus may be associated with a major vascular injury On the other hand, total rupture with displacement of the bronchial fragments may be accompanied by an insignificant injury to the vessels and very little bleeding Rupture of one of the upper lobe bronchi may then produce total atelectasis of the lobe but the patient may be entirely free of symptoms

Roentgenologic findings Roentgen examination of the thorax in the acute phase may reveal atelectasis of the lung adjacent to the injured bronchus as the only sign Multiple lesions, such as pneumothorax, mediastinal emphysema, *atelectasis, hemothorax, and infiltration of the lung are usually evident,* however The latter may be caused by aspirated blood or by hemorrhage into the lacerated lung Laceration of the lung following trauma is not uncommon in children Signs of mediastinitis and empyema may develop during the days that follow if the injury has been overlooked or neglected



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Fig. 4. Air bronchograms illustrating normal appearances in the left posterior oblique position.

bag insufflator. Leakage of the medium into the adjacent lung tissue was observed at the origin of the apical bronchus of the lower lobe (Fig. 2).

Following bronchography, thoracotomy was performed and the bronchial rupture was sutured; this was within 8 hours of the accident. The rupture involved the apical bronchus to the lower lobe, exactly at its origin from the left lower lobe bronchus. Bleeding below the left hemidiaphragm was noted during the operation; this was caused by splenic rupture and splenectomy was performed.

The boy improved rapidly during the postoperative period. Repeat bronchography was carried out about two months after the accident (Fig. 3) and depicted normal bronchial anatomy. Roentgen examination of the lung six months after operation revealed minimal interlobar thickening between the apical segment of the lower lobe and the apical segment of the upper lobe.

Discussion

The necessity for swift action in traffic accidents makes the establishment of a rapid and accurate diagnosis essential. This is especially true in injuries of the thorax. While the literature contains reports of repair of bronchial rupture up to several months after the actual injury, the injured lung has generally had to be

removed because of mediastinitis and empyema This eventuality could probably be avoided if treatment had been started soon after the accident Prompt and accurate roentgenologic diagnosis can render this possible

Should changes such as atelectasis and pneumothorax suggest rupture the investigation should be continued until the basic lesion becomes obvious Following conventional chest films well penetrated films of the trachea and the main bronchi should be obtained with the injured side of the chest rotated posteriorly about 45° (NORLIN 1955) (Fig 4) A break in the outline of a main bronchus will thus establish evidence of its rupture Should this procedure not prove diagnostic emergency bronchography must be performed The contrast medium should be injected with caution and monitored fluoroscopy the injection must be stopped immediately any leakage is observed Films are exposed with the patient in the supine lateral decubitus and 45° posterior oblique positions

It is pointed out in the literature that it would be advantageous to perform bronchoscopy as a first procedure instead of bronchography Bronchial bleeding may make this procedure difficult and dangerous (CARLENS) and for this reason bronchography is probably the procedure of choice

The present case shows that there are means of obtaining a quick and accurate diagnosis of traumatic bronchial rupture It should be possible to arrive at the diagnosis even if the patient has sustained other serious injuries

Acknowledgement

The author takes this opportunity of expressing his sincere thanks to M B Ozonoff for his criticism and stimulating suggestions

SUMMARY

A case is reported in which traumatic bronchial rupture was diagnosed by bronchography in the acute phase The diagnosis led to plastic surgery with bronchial anastomosis within eight hours of the accident

ZUSAMMENFASSUNG

Ein Fall von traumatischer Bronchusruptur konnte im akuten Stadium erkannt werden Durch die prompte Diagnose konnte innerhalb acht Stunden der Schaden operativ repariert werden

RÉSUMÉ

Présentation d un cas ou la rupture traumatique d une bronche a été diagnostiquée par bronchographie au stade aigu Ce diagnostic a permis de faire une opération plastique avec anastomose bronchique dans les huit heures après l accident

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ROENTGENOGRAPHIC STUDY OF THE SOFT PALATE DURING PHONATION AT HIGH AMBIENT AIR PRESSURE

by

G BENGTSSON and B SONESSON

The voice of the diver generally attains a typical nasal quality at deep underwater levels and the distortion often makes it difficult for him to maintain effective communication It is known that the soft palate is of great importance in closing the passage between the oropharynx and the nasopharynx during normal speech production, and it is also recognized that incomplete closure of the velopharyngeal valve will result in the sound wave being shunted up to the nasal cavities thus producing a nasal voice It was considered important to investigate if the velopharyngeal valve functions properly when exposed to elevated air pressure or pressure at deep underwater levels The velopharyngeal function in connected speech has been recorded in an excellent study by BJORK (1961) by means of tomography and cineradiography but as far as we have been able to ascertain from the literature no roentgenographic study of the speech organs during phonation at high ambient pressure seems to have been made The mechanism underlying the change in the speech sound of the diver has in fact not been satisfactorily explained until recently (FANT & SONESSON 1964)

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Fig 1 a) Lateral roentgenogram of the velopharyngeal region during phonation at normal atmospheric pressure b) Lateral roentgenogram of the velopharyngeal region during phonation at high ambient air pressure (6 ata corresponding to the pressure at 50 m diving depth) Complete closure of the velopharynx

It was stressed from an acoustic analysis (Fant 1962, unpublished data) that there might be a shunting mechanism in the vocal tract producing the nasal speech The present study was therefore started to gain further insight into the acoustic physiology of the voice organs, being part of a research program to investigate different factors influencing the diver s speech and particularly those causing the nasal sound

The study of the functional anatomy of the soft palate during high ambient air pressure was made possible by using roentgen equipment in the decompression chamber on board the diver ship 'Belos of the Swedish Navy The air pressure in the decompression chamber could be elevated to levels corresponding to the actual pressures at various diving depths

Material and Method The roentgen tube was attached to the wall of the decompression chamber and orientated in the horizontal plane The distance between the anode and the median plane of the head of the subject was 100 cm and that between the median plane and the film plane was 9 cm The

exposure data were 120 kV at 12 mAs exposure time 0 08 sec film CFA Victor developed for 3 5 min at 21° in Tetenal Roentgen Rapid developer and fixated in Amfix Ultrarapid fixator The subject was seated upright without any apparatus to hold the head rigid

Simultaneous recording of the speech sound was carried out with a battery operated tape recorder and a dynamic microphone, a speaking distance of 5 cm to the microphone was maintained Two series of lateral roentgenograms were obtained of the upper part of the vocal tract, i e of the pharynx, the mouth and the nose one at 1 ata (= ordinary atmospheric pressure) and the other at 6 ata (= the pressure corresponding to the pressure at 50 m under surface of the water) Two roentgenograms were obtained of each subject in each series, one on quiet respiration and the other on phonation of a sustained vowel (an e) at medium intensity and at a frequency corresponding to ordinary speech The experimental group consisted of two healthy adults who had normal speech function and no disturbance of the voice organs

In a special test series the speech sound of four normal subjects uttering a number of non descript syllables comprising various phonetic combinations were recorded at normal and increased air pressures Details of this investigation have been published elsewhere (FANT & SONESSON 1964)

Results and Discussion

The roentgenograms bore the same appearances during respiration at normal and elevated air pressure (6 ata) the soft palate hanging down with the uvula resting on the posterior part of the tongue No change in shape was evident and the position of the soft palate when the ambient air pressure was elevated to 6 ata was the same as compared with that at normal air pressure

The roentgenograms revealed that the soft palate during phonation at ordinary atmospheric air pressure was elevated and curved and came in intimate contact with the posterior wall of the pharynx (Fig 1 a) During phonation at increased air pressure (equal to that at 50 m diving depth) the soft palate lay in the same position efficiently closing the passage up to the nasopharynx (Fig 1 b) The speech sound recorded simultaneously on the tape recorder was of the nasal type indicating a shunting mechanism somewhere in the vocal tract no anatomic shunt could however be identified in the roentgenograms

The nasal quality of the speech is occasionally attributed to a shunting mechanism the sound wave being transmitted up to the nasal cavities through an insufficient velopharyngeal valve This roentgenographic study indicates however that the soft palate does not contribute to a shunting mechanism

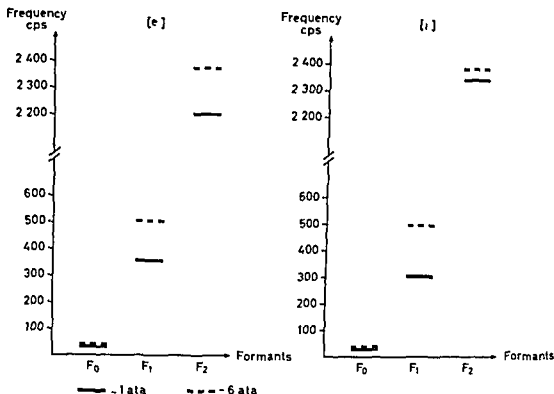


Fig. 2. Graphical representation of speech spectrograms of the vowels e and i obtained in the decompression chamber at normal (1 ata) and raised air pressure (6 ata). Elevation of the ambient air pressure caused no alteration in the fundamental tone (F_0) of the voice, whereas the frequency of the first (F_1) and second (F_2) formants increased.

producing nasal speech at high ambient air pressure. Another possible explanation might be a feed back mechanism in the larynx due to incompletely closed vocal folds during phonation. However, in the present study such a recurrent leakage of the sound wave through the glottis seemed unlikely, additional roentgenograms obtained in the frontal plane through the vocal folds failed to reveal incomplete closure of the glottis when the subjects were exposed to high ambient pressures (BENGTSSON & SONESSON 1964, unpublished data).

The results from the spectrographic analysis of the tape recording in the decompression chamber during these experiments have been published elsewhere (FANT & SONESSON 1964). A brief comment will be made, however, since theoretically they may provide an explanation of the shunting effect and the nasal speech from an acoustic point of view. The spectrographic analysis indicated that the frequency of certain overtones of the speech sound, the so called first formant (F_1) and second formant (F_2), is increased when

the air pressure is raised In fact, F_1 is increased more than F_2 so that they will come closer to each other (Fig 2) From the auditive point of view this will be interpreted as nasal speech sound for certain vowels The increased density of the air during compression makes the air column in the vocal tract heavier which in turn is supposed to produce vibrations in the pharyngeal walls This leakage of sound energy will result in a nasal voice quality when the subject is exposed to high ambient pressure (FANT & SONESSON 1964)

Acknowledgement

The work was supported by the Swedish Medical Research Council (project No B67 14X 129 02)

SUMMARY

A roentgenographic study was made of the functional anatomy of the soft palate with the subject in a decompression chamber in which the pressure could be elevated above ordinary atmospheric air pressure The role of the increased density of the air in producing nasal speech *is discussed*

ZUSAMMENFASSUNG

In einer Druckkammer in der der Druck uber den Normalluftdruck *erhoht werden konnte* wurden rontgenologische Funktionsuntersuchungen des weichen Gaumens angestellt Der Einfluss des Hochdruckes auf die Vorbringung einer nasalen Stimme wird erortert

RÉSUMÉ

Les auteurs ont étudié radiographiquement l anatomie *fonctionnelle* du palais mou chez un sujet placé dans une chambre de decompression ou la pression peut etre supérieure à la pression atmosphérique ordinaire Ils examinent le role de l augmentation de densité de l air dans l apparition du *nasonnement*

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INTEGRAL DOSE IN 70 MM FLUOROGRAPHY OF THE GASTRODUODENAL TRACT

by

C. CARLSSON and J. KAUDE

Image intensification has led to changes not only in the fluoroscopic procedure in diagnostic radiology but also made it possible to supplement or change the conventional methods of spot filming. The image on the output screen of an image intensifier can be recorded by cinefluorography or, for example, by a 70 mm spot film camera. If equal informative quality can be obtained, full size roentgenograms may be replaced by films of smaller size, by 70 mm film, for instance. With the use of 70 mm fluorography in routine gastroduodenal studies, the examination time may be reduced and the need of assistance will be less; such films are moreover cheaper and easier to file. The main advantage of 70 mm fluorography in connection with an image intensifier is, however, the reduction of the radiation energy delivered to the patient.

FEDDEMA (1962) reported that 70 mm single films of image quality equal to full size films could be obtained with 5 % of the tube current at constant voltage. SAMUEL & SUMERLING (1964) measured the entrance exposure in phantom

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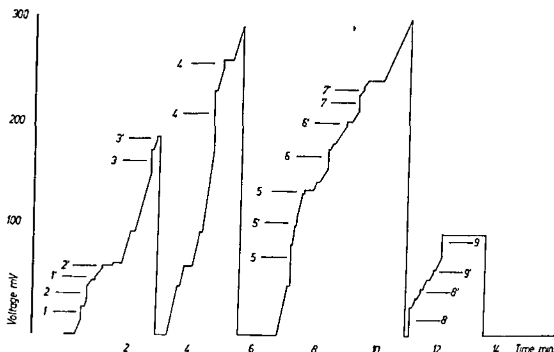
studies with an ionization chamber With 70 mm fluorography they reported an exposure of 25 % to 66 % of that used for full size radiography BERNBAUM & LIPSON (1964) used equipment similar to that employed in the present investigation for the measurement of the incident radiation energy They found that for 70 mm fluorography the incident energy was 5 % to 10 % of that required for full size radiography

The ratio of the radiation energy transmitted to the patient from 70 mm fluorography and full size radiography has thus been determined by means of observed mAs values by exposure measurements with ionization chambers and by measuring the incident energy, or, as in this report, the integral dose Provided the same roentgen tube at constant voltage is used with the same field area and tube focus/film distance for both the 70 mm and the full size techniques the relations obtained will be the same whatever method of measurement is employed

The present investigation was carried out in clinical work as part of a comparative study on the diagnostic accuracy of 70 mm and respectively full size radiography of the gastroduodenal tract The integral dose was determined in 150 cases out of a total of 320 examinations Each examination included fluoroscopy with an image intensifier and television output full size radiography and 70 mm fluorography Films of both sizes were obtained with the patient in the same position with the same compression and with the same amount of contrast medium in the stomach or the duodenal bulb By this comparison of the two techniques under the same conditions as are commonly encountered in clinical work it was possible to make a direct comparison of the measurements of the integral doses

The tube voltage was 125 kV and the exposure time was approximately the same for the 70 mm and the full size filming The tube current varied considerably with the use of image intensifier and a 0 3 mm tube focus for 70 mm fluorography For full size radiographs CAWO *universal* intensifier screens were employed and the films were obtained with a 1 2 mm tube focus The distances from the tube focus were to the table top 43 5 cm to the full size film between 80 and 90 cm and to the input screen of the image intensifier between 85 and 95 cm In a number of cases geometric magnification by a factor of approximately 1 8 to 1 9 was applied

The technique described by one of the present authors (CARLSSON 1963 1965) was used in the measurement of the integral doses The equipment consisted of a plane parallel ionization chamber a condenser an electrometer and a recorder The ionization current which is proportional to the product of the exposure rate and field area charges the condenser the voltage of the condenser is recorded, and the integral dose is calculated from these records



Schematic illustration of examinations of the gastroduodenal tract with conventional and 70 mm techniques in an obese patient with hiatus hernia The 70 mm films were obtained with geometric magnification
1 2 — full size films of the cardia
3 4 5 — full size films of stomach with patient prone supine and erect
6 7 8 9 — spot films of duodenal bulb Primed numbers indicate the corresponding 70 mm films two 70 mm films were used for recording of the stomach with the patient erect (5)

Results and Discussion

An example of the records is given in Fig 1, showing the increase in voltage of the condenser with examination time The sloping lines indicate fluoroscopy (slow exposure rate) and the horizontal lines indicate that the roentgen tube was switched off The vertical lines signify filming (high exposure rate) The full size roentgenograms are marked with unprimed numbers and the 70 mm fluorograms with primed numbers There is only a small contribution to the integral dose from the 70 mm filming a sensitive scale of the electrometer had to be used in order to obtain measurable records of the 70 mm fluorograms

The total integral dose calculated from the diagram presented was 16 3 kg rad, of which 10 4 kg rad were from fluoroscopy 5 1 kg rad from nine full size roentgenograms, and about 0 8 kg rad from ten 70 mm films The integral dose per 70 mm film was approximately 13 % of that required for conventional radiography Two 70 mm films were needed to obtain a record of the stomach

with the patient standing The integral dose for these 70 mm films was 23 % of that obtaining for one full size roentgenogram of the stomach

The mean integral dose for a single 70 mm film in this series was 12 % of the integral dose for obtaining a full size roentgenogram The integral dose in a complete gastroduodenal examination was reduced on an average to 13 % of that required in conventional radiography i e by a reduction factor of 7 8 ± 1 4 The somewhat lower reduction in integral dose per patient is explained by a higher number of exposures that in some cases are necessary for filming of the stomach (for instance numbers 5 and 5 in the diagram) When geometric magnification (enlargement factor approximately 1 8 to 1 9) was applied in 70 mm fluorography the integral dose was reduced to 16 % or by a factor of 6 3 ± 1 3

The decrease in integral dose was not to any extent influenced by the patient s habitus

The dose reduction was found to be less in the present investigation than that reported by FEDDEMA and BERANBAUM & LIGNON It was however higher than reported by SAMUEL & SUMERLING in their phantom studies The different results from the various investigations reported may depend on variations in examination techniques voltage and intensifier screens the quality of the image intensifier film sensitivity and processing

If adequate information can be obtained the considerable decrease in the integral dose justifies the employment of 70 mm fluorography for routine roentgendiagnostic procedures

Acknowledgement

The authors are indebted to Mr Robert Krantz for technical assistance

SUMMARY

The integral doses per film and patient were measured in a comparative clinical investigation with 70 mm fluorography and conventional roentgenography of the gastroduodenal tract The dose with 70-mm fluorography was found to be approximately only 12 % to 16 % of that required with the conventional technique

ZUSAMMENFASSUNG

Die Integraldosis bei Röntgenuntersuchung des Magens mit 70 mm Bildverstarker Aufnahmeverfahren und konventionell r Grossformat Aufnahmetechnik wurde in klinischer Arbeit ermittelt und verglichen Bei der Anwendung der 70-mm Methode betrug die Integraldosis nur 12 bis 16 von d r Dosis die fur die Untersuchung mit Grossformat Aufnahmen erforderl ch war

RÉSUMÉ

Les auteurs ont mesuré dans un travail clinique comparatif les doses intégrales par film et par malade dans l'examen radiophotographique en 70 mm et dans la radiographie ordinaire de l'estomac et du duodénum. La dose en radiophotographie sur film de 70 mm ne représente qu'environ 12 % à 16 % de celle que nécessite la technique classique.

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SERVICES DE NEURORADIOLOGIE DE STRASBOURG ET DE COLMAR FRANCE

DILATATION DE LA CITERNE PÉRICAROTIDIENNE SUSCAVERNEUSE

par

A. WACKENHEIM et J. P. BRAUN

Le radio diagnostic des tumeurs intracrâniennes par encéphalographie gazeuse est basé en grande partie sur l'étude des citernes, plus particulièrement lorsqu'il s'agit de tumeurs extracérébrales. Le développement de cette notion de valeur diagnostique du système cisternal est dû à l'école du professeur LINDGREN. La monographie de B. LILLIEQUIST nous apporte un ouvrage de base sur ce système cisternal. Depuis plusieurs années, nous nous *intéressons* à ces problèmes, surtout à ceux des tumeurs de la fosse postérieure. Dans ce travail, nous rapportons notre expérience de la *citerne péricarotidienne* que nous avons trouvée nettement dilatée dans quatre cas de tumeur de la région sellaire.

Définition anatomique de la citerne péricarotidienne suscaverneuse. Pour devenir intracrânienne, la carotide interne traverse la dure-mère du sinus caverneux. Cette sortie du sinus correspond angiographiquement à la naissance de l'artère ophtalmique et à la *pénétration* de l'artère carotide dans la citerne opto-chiasmatique. Le passage dans la citerne *correspond à la* fin du segment C1 de Fischer et à l'extrémité antéro-inférieure de cette gouttière sous-arach

Soumis à la Rédaction le 17 Mars 1966

noïdienne limitée à l intérieur par le chiasma et à l'extérieur par l'uncus du lobe temporal Cet espace péricarotidien peut être appelé 'citerne péricarotidienne sus caverneuse' car il correspond à un manchon fourré d'arachnoïde qui accompagne la carotide sur un certain trajet dans cette traversée dure mérienne Ces manchons sont fréquents tant au niveau des nerfs que des artères (espaces de Virchow Robin) Le trajet intraarachnoïdien de la carotide est très court et variable car elle se divise rapidement en artère cérébrale antérieure et moyenne Cette bifurcation marque la fin de la citerne carotidienne L'espace sous arachnoïdien péricarotidien communique avec la citerne de la lame terminale en avant et avec la citerne sylvienne latéralement

Habituellement non insufflée, la citerne péricarotidienne apparaît nettement dans les quatre cas de processus expansif que nous rapportons Il s'agit de quatre cas de masses de la région sellaire, soit d un cas de méningiome olfactif, d un cas d infection sphénoïdale avec thrombose du sinus caverneux, d'un cas de méningiome parenchymateux de l apophyse clinoïde antérieure et d un cas d extension intracrânienne d adénome éosinophile de l'hypophyse

Cas 1 (Fig 1) Homme de 41 ans porteur d un méningiome du sillon olfactif La tumeur est fortement vascularisée L artère cérébrale antérieure est prise dans le pole postérieur de la tumeur

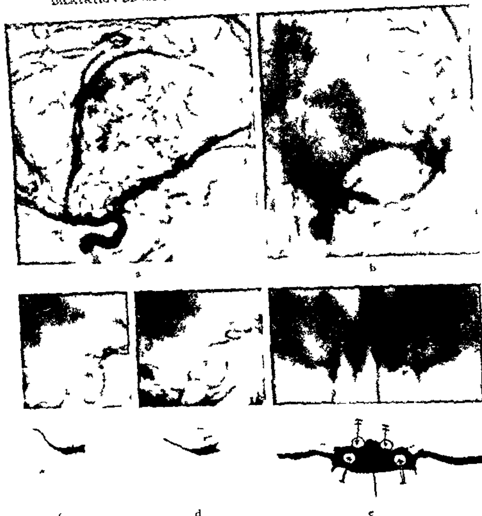
L angiographie carotidienne montre les signes caractéristiques d un méningiome olfactif = refoulement et soulèvement de l artere cérébrale antérieure et de ses branches vascularisation tumorale de néovaisseaux On note d autre part d importantes modifications pariétales du segment carotidien C1 dont la paroi supérieure est mamelonnée Ces anomalies se retrouvent sur les deux premiers centimètres du segment M1

Encephalographie gazeuse fractionnee En dehors des signes d une masse expansive de la fosse cérébrale antérieure nous trouvons une image anormale de dilatation de la citerne péri carotidienne Une lame aérienne se projette en effect en dessous des apophyses clinoïdes antérieures Cette lame correspond dans sa partie postérieure au segment C1 et dans sa partie antérieure au départ de l artère ophtalmique En comparant cette image a celle de l angio graphie il ne fait pas de doute qu elle corresponde au manchon de Virchow Robin qui accompagne le segment C1 et la naissance de l artère ophtalmique Ce manchon est particu lièrement bien visible en raison de l absence d air dans la citerne opto chiasmatique

Cas 2 (Fig 2) Homme de 39 ans diabétique avec infections multiples comprenant un phlégmon rétro orbitaire gauche avec nécrose de la voute palatine de l éthmoïde postérieur et du sphénoïde et paralysie des IIe IIIe Ve et VIIe paires craniennes gauches hémiplégie droite progressive Il s agit vraisemblablement d une thrombophlébite cérébrale Les radio graphies craniennes montrent une masse ostéolytique occupant toute la région éthmoïdo sphénoïdale gauche

L angiographie carotidienne gauche montre un déplacement externe avec soulèvement de segment A1 permettant de conclure a l extension supra latéro sellaire de la masse sphéno éthmoïdale

Encephalographie gazeuse fractionnee Dans ce cas la citerne opto chiasmatique est insufflée et masque la partie postérieure de la citerne péricarotidienne Sa partie antérieure est toutefois



F g 1 a) et b) Ang ographie c rot d enne de p ofil et d f ce montrant les mod fications du segment C1 a n qu l ens mble des an mal es dues au mening ome olfactif c) et d) Cite ne perica o- t di nne d latee a ec on prolong ment ophtalm que e) Tomograph e f ontale montrant l opac te des gments C1 gauche et droit entourés d a r dans la citerne pé ica otid enne (→→) La citerne c mn u iqu a l extér eur ave la tern syl i nne et à l intér eur avec la citerne opto-ch asmatique O d t ngue outr les opa ites opt ques (→→)

bien visible projetée en avant de la corticale sellaire antérieure sous forme d un ruban clair de 1 cm de long Les tomographies sagittales et parasagittales gauches permettent d isoler l image de la citerne péricarotidienne dilatee En confrontant cette image avec l angiographie carotidienne gauche on constate qu il s a it bien d un espace de Virchow Robin *correspondant* dans sa part e antérieure à C1 et dans sa partie postérieure a la bifurcation Ces deux parties

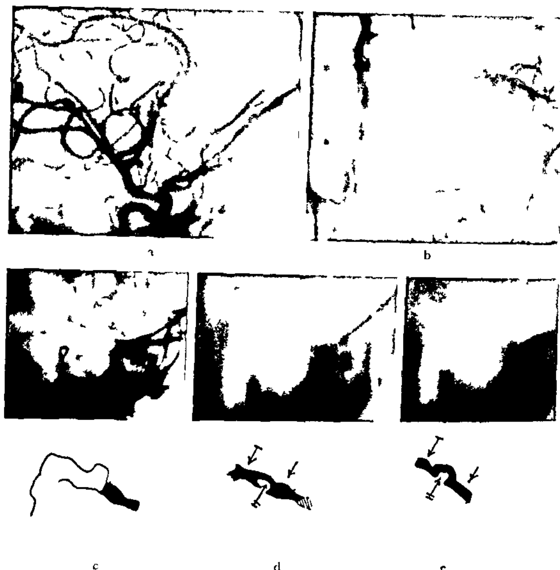


Fig 2 a) Angiographie carotidienne de profil montrant le segment C1 abaissé et le segment A1 soulevé b) Angiographie carotidienne correspondante de profil montrant le déplacement latéral externe et le soulèvement du segment A1 et le déplacement externe du segment C1 c) Encephalographie gazeuse fractionnee montrant la partie antérieure de la citerne péricarotidienne dilatée la partie postérieure se confondant avec la clarté de la citerne opto chiasmatique d) et e) Tomographies parasagittales permettant d individualiser toute la citerne péricarotidienne dilatée tant dans le segment C1 (⟶) que dans le segment de la bifurcation (⟷) opacité carotidienne a la limite de ces deux segments (⟼)

sont d ailleurs séparées par une opacité arrondie correspondant a la coupe optique d une artère de la bifurcation

Cas 3 (Fig 3) Femme de 42 ans hospitalisée pour *méningiome parenchymateux inséré* sur l apophyse clinoïde antérieure gauche La tumeur s étend dans la fosse temporale antérieure *et dans la région frontale*



Fig 3 Ang g aphi ca ot dienne mo it ant les mod ficat ons par ma se étendue a l etage ante ieur Note l importance des alterations du segment C1

L an io aphie carotid enne montre les signes d une masse arrondie de la région fronto-temporale gauche et en parti ulier le rétrecissement et l abaissement du segment C1 du siphon carotidien

L encephalo raphie gazeuse fractionnée montre aussi une image nette de citerne péricarotidienne occupant la région correspondant au segment C1 Cette citerne est nettement dilatée et bifu quée a son extrémité postérieure là ou elle correspond a la division du siphon en segment A1 et M1 La clarté aérienne entoure d ailleurs la coupe optique du segment M1 Nous ne disposons malheureusement pas d examen tomographique de la citern dans ce cas

Cas 4 (Fig 4) Femme de 24 ans admise pour récidive d un adénome éosinophile de l hypophyse avec cécité de l oeil gauche

L ang o raphie ca otid enne montre les signes indirects d extension sus sellaire d une masse qui soulève le siphon corotidien et le segment A1

L encephalo aphie gazeuse fractionn e permet d obtenir une très belle image de citerne péri carotidienne correpondant tant au segment C1 qu a la partie initiale de l artere ophtalmique Dans ce cas la citerne n est pas très dilatée mais son insufflation est compl te sur tout le segment C1 depuis la fourche A1—M1 jusqu au départ de l artere ophtalmique

Discussion

La citerne péricarotidienne sus caverneuse est indiscutablement dilatée dans nos observations Cette dilatation est pathologique car nous ne l avons pas rencontrée ailleurs Le point commun de nos quatre observations est

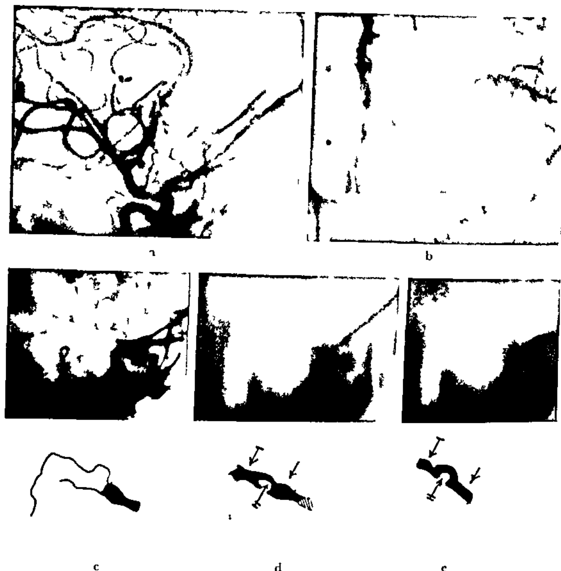


Fig 2 a) Angiographie carotidienne de profil montrant le segment C1 abaissé et le segment M1 soulevé b) Angiographie carotidienne correspondante de profil montrant le déplacement latéral externe et le soulèvement du segment M1 et le deplacement externe du segment C1 c) Encephalographie gazeuse fractionnée montrant la partie antérieure de la citerne péricarotidienne dilatée *la partie postérieure se confondant avec la clarté de la citerne opto chiasmatique d) et e) Tomo*graphies parasagittales permettant d individualiser toute la citerne péricarotidienne dilatée tant dans le segment C1 (⟶) que dans le segment de la bifurcation (⟶) opacité carotidienne a la limite de ces deux segments (⟶)

sont d ailleurs séparées par une opacité arrondie correspondant à la coupe optique d une artere de la bifurcation

Cas 3 (*Fig 3*) Femme de 42 ans hospitalisée pour méningiome parenchymateux inséré sur l apophyse clinoide antérieure gauche La tumeur s étend dans la fosse temporale antérieure et dans la région frontale

tion du segment suscaverneux du siphon carotidien Dans certains cas, la citerne est également ouverte le long de l insertion de l artere ophtalmique Cette dilatation cisternale traduisant une hypertension locale prend la valeur d un signe indirect mais caractéristique d un processus expansif de cette région L image encéphalographique de citerne péricarotidienne dilatée peut n apparaitre nettement qu en tomographie Elle rentre en tout cas dans le cadre des hydrocéphalies externes par blocage loco régional du liquide céphalo rachidien

L image de citerne péricarotidienne déja signalée par LEWTAS et JEFFERSON ne doit pas etre interprétée dans le sens d un soulevement de la partie antérieure de la citerne opto chiasmatique ou d une anomalie des citernes de la lame terminale et de la vallée sylvienne

RÉSUMÉ

Les auteurs rapportent quatre cas de dilatation de la citerne péricarotidienne et pensent que cette anomalie représente un signe d hypertension loco-régionale par masse expansive de la région sellaire

SUMMARY

Four cases of dilatation of the pericarotid cistern are reported upon It is suggested that this anomaly is a sign of regional hypertension caused by an expansive lesion in the sella region

ZUSAMMENFASSUNG

Es wird uber vier Falle von Dilatation der Cisterna péricarotidienne berichtet und es wird angenommen dass diese Anomalie ein Zeichen von regionalem Überdruck durch eine expansive Lesion der Sella Region ist

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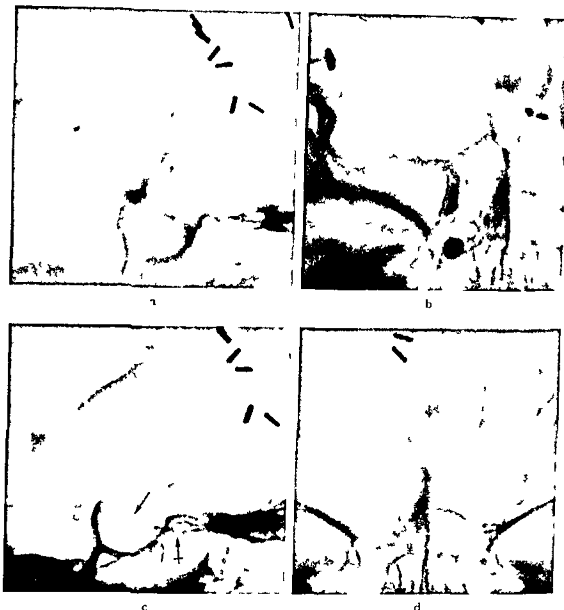


Fig. 4. a) et b) Angiographie carotidienne montrant les modifications par masse de la région sellaire et suprasellaire. c) et d) Encéphalographie gazeuse fractionnée. En (c), on distingue nettement la citerne péricarotidienne correspondant à la projection latérale du segment C1 (→) et de la partie initiale de l'artère ophtalmique (+→).

l'existence d'une masse expansive de la région sellaire. Nous pensons que de telles masses sont responsables d'une hypertension régionale qui, transmise à la citerne péricarotidienne, provoque sa dilatation par *accumulation et blocage* de liquide céphalorachidien. Cette ouverture avec possibilité d'insufflation de la citerne péricarotidienne devient possible par le *déplacement* ou la *dévia-*

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ROENTGENOLOGIC EVALUATION OF CRANIAL SIZE IN CHILDREN

A new index

by

STEN CRONQVIST

The roentgenologic evaluation of the size of the cranium is generally based upon the presence of a disproportion between the neurocranium and the face Although measurement data on length width and height of the skull in different age groups are available (HAAS 1952) the figures differ widely so that the evaluation of these interrelationships are generally made by inspection based upon experience (DORST 1964) The increasing number of neuroradiologic problems especially in children have however accentuated the need for more objective criteria and this initiated the attempt to construct new cranial indices The indices have now been used in a series of children under 7 years of age

It was considered of importance in producing the index that the necessary measurements should be obtained from routine skull films so that the index could be of practical value and used in everyday work without any special views

Roentgen examinations of the skull in our department are performed with a Lysholm skull table (FFD 80 cm) and include films in the axial, lateral postero anterior and anteroposterior projections Only the lateral and antero

From Roentgendiagnostic Department I (Director Prof O Olsson) University Hospital Lund Sweden Submitted for publication 16 November 1966

Book reviews

PRINCIPLES OF X RAY DIAGNOSIS OF THE SKULL By C H DuBoulay 370 pages 364 figures Butterworths London 1965 Price 150 Sh

The book which is written around a collection of cases covers all aspects of the roentgen examination of the skull The author follows the traditional method of describing cerebral radiology although he introduces the subject in an unorthodox way the first chapter dealing with changes caused by raised intracranial pressures The chapters that follow describe changes in the vault the sella turcica and the base of the skull as well as the appearances of different kinds of intracranial calcifications

The chapters dealing with raised intracranial pressure and changes in and around the sella turcica are of special interest the latter are considered in detail and their appearances in children are discussed The book contains many statements founded upon the author s comprehensive knowledge of his subject

The book can be read from cover to cover but also a reader interested in a special problem can find his way through the text with the help of a vast number of cross references This however leads to certain difficulties The bony changes caused by meningioma are for instance not collected in one place but appear under a large variety of headings Repetitions are present despite the cross references and the same description appears in several places in the text Certain unusual conditions are dealt with rather cursorily and not much information about them is obtained

The author has included a brief chapter on the paranasal sinuses the orbit and the nasopharynx this does not stand out as well as the rest of the book as the problems are more arbitrarily treated The radiologic examination of the inner and middle ear are only touched upon in the last chapter which also contains a description of the technical performance of the skull examination The author relates the recommendation issued by the World Federation of Neurology for standardization of the technique with minor modifications practised by himself

The work contains many illustrations mostly of high quality and well suited to show the changes described Most of them are large which in the opinion of the reviewer is a distinct advantage The legends are detailed and much can be learned just by reading them and looking at the illustrations

A main bibliography appears at the end of the book but there are no references in the text

B Liliequist

BONE TUMOURS By William D Graham 139 pages 48 figures and 3 tables Butterworths London 1966 Price 52/6d

Previous works on bone tumours usually by American pathologists have been mainly centred upon the diagnosis The present little book has been arranged by a surgeon who is obviously a first class teacher Treatment by surgery and radiotherapy as well as chemical means is dealt with in detail in a special chapter Skeletal metastases are discussed from all aspects The few roentgenograms that are included are mostly excellent and serve as good illustrative examples It seems however that some extremely rare types of bone tumours which are dealt with very briefly could just as well have been omitted

The book forms a brief survey of these conditions and as such certainly fills a need

Ake Lindbom

Skull examinations The mean value for the cranial index based upon normal skull films, according to formula (1) is 53 5±2×1 21 This means that normal variations between a maximum of 55 92 (56) and a minimum of 51 08 (51) are permitted

The normal values for individual cranial measurements of length, height and width divided by the maximal distance between the necks of the mandible were also determined, and are given below

$\frac{L}{M}\times 10$	m=20 57 SD= 0 80	m+2×SD=22 17 (22 2) m−2×SD=18 97 (19 0)	(2)
$\frac{H}{M}\times 10$	m=15 67 SD= 0 76	m+2×SD=19 19 (17 2) m −2×SD=14 15 (14 2)	(3)
$\frac{W}{M}\times 10$	m=17 27 SD= 0 60	m+2×SD=18 47 (18 5) m−2×SD=16 7 (16 0)	(4)

Pneumographic examinations The films from a pneumographic study are not necessarily identical with routine skull films It was therefore considered important to correlate the index obtained from skull examinations with that obtained from pneumographic studies Only examinations performed in close time relation to each other were used Statistically a good correlation was found

$$r=0\,97 \quad SD\ diff=1\,10 \quad m\ diff=+0\,43 \qquad (5)$$

Pathologic cases

These cases were separated into groups according to the type of finding hydrocephalus 77 cases subdural haematoma 20 cases atrophy 53 cases and various maldevelopments 24 cases

Hydrocephalus Forty two of the 77 cases with hydrocephalus verified by encephalography or ventriculography were of the non communicating type and 28 were of the communicating type An expansive lesion in the posterior fossa or in the third ventricle was present in 7 cases The cranial index was determined for the first two groups of hydrocephalus cases from measurements on films from the earliest examination The mean value was found to be 61 7 The non communicating type had a value of 62 3 and the communicating a value of 60 7 There were 7 cases with a cranial index below the value considered as the maximum upper limit for normal cases six belonged to the group with non communicating hydrocephalus and in five of these a repeat examination revealed a rapid increase of the index

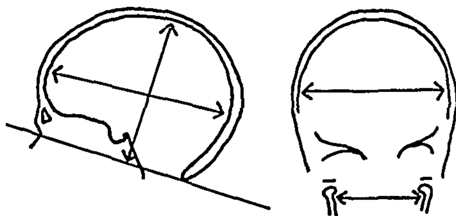


Fig 1 Schematic drawings of the skull indicating the points between which measurements are performed

posterior films are used in the measurements necessary for the cranial index In children, the anteroposterior film is routinely obtained with the tube angulated 15° cranially

Technique The measurements are made between the internal tables of the skull and include the greatest length (L), greatest width (W), and greatest height (H) The latter is the maximum perpendicular distance between the vault of the skull and a line drawn from the nasion to the posterior margin of the foramen magnum The maximum distance (M) between the inner margins of the two necks of the mandible is measured in the a p film (Fig 1)

The cranial index (C index) is then obtained from the formula

$$\text{C index} = \frac{L + H + W}{M} \times 10 \qquad (1)$$

Material The study was confined to the roentgen examinations of children under 7 years of age The material included 96 cases in which conventional skull examinations alone had been made and 177 cases examined by encephalography or ventriculography In most of the latter cases, conventional films were also available Repeat examinations had been carried out in a number of cases

Normal cases

In order to obtain normal values for the cranial index, cases with normal encephalographic findings as well as normal skull films were selected Only 22 encephalographies were considered completely normal

Table 2

Cranial index related to indication for examination

Indication for examination	Group with index < 56				Group with index > 56				Total number of cases in both groups
	Ordinary skull examin	Encephalographies		Number of cases	Ordinary skull examin	Encephalographies		Number of cases	
		Normal	Pathologic			Normal	Pathologic		
Trauma	14	1	1	16	3	—	2	5	21
Increase in head size	1	—	3	4	—	—	1	1	5
Retarded development	6	2	12	20	—	—	4	4	24
Epilepsy	27	9	9	40	16	—	11	27	67
Miscellaneous	4	9	7	20	3	—	2	5	25
Myelomeningocele	7	1	1	9	2	—	—	2	11
Total	54	22	33	109	24	—	20	44	153

of the haematoma prior to the roentgen examination In the fifteen cases with an increased cranial index the mean value was 59 5 a value lying between normal maximal limits and the mean value in cases of hydrocephalus

Atrophy Encephalographic studies had in a large number of cases revealed either cortical or what was considered central atrophy or both The majority or 33 out of 53 cases, had a cranial index within *normal limits* In these 33 cases cortical and central atrophy was present in six and eighteen respectively Nine cases had both types Four of the 20 cases with an increased index had cortical, and six had central atrophy while eight cases had both (Table 1) Those of the 20 cases with only central atrophy had a higher value than those with only cortical atrophy or 58 1 and 57 7 *respectively The index* was still higher in cases with both kinds of atrophy (59 4) It was evident in cases with an index within normal limits that those with central atrophy presented values close to the lower normal limits (Table 1)

Cranial maldevelopment Twenty four cases belong to this rather heterogeneous group No conclusion as to the relation between the cranial index and different types of maldevelopment is possible However 12 *of the cases had a* cranial index above a normal value In four of these encephalography had been performed and revealed changes *other than those* due to hydrocephalus

Table 1

Cranial indices in cases of atrophy

Encephalographic findings	C/index normal	C/index pathologic	Difference
Cortical atrophy	53 8 n = 6	57 6 n = 4	3 8
Cortical and central atrophy	54 9 n = 9	59 4 n = 8	4 5
Central atrophy	51 9 n = 18	58 1 n = 8	6 2

As was done in the group of normal cases, the values of the greatest length, height and width were divided by the maximal distance between the two necks of the mandible The mean values were

$$\frac{L}{M}\times 10 = 24\ 1 \quad \frac{H}{M}\times 10 = 18\ 5 \quad \frac{W}{M}\times 10 = 19\ 0$$

Out of the 70 cases with hydrocephalus not caused by expansive lesions, the quotient $\frac{L}{M}$ was at or below the normal (22 2) in 12 cases Normal values for $\frac{H}{M}$ and $\frac{W}{M}$ were noted in 17 and 30 cases, respectively Therefore, of the cases with hydrocephalus the $\frac{L}{M}$ quotient was pathologic in 83 %, the $\frac{H}{M}$ quotient in 75 6 %, and the $\frac{W}{M}$ quotient in 43 % However, the cases with a normal value for $\frac{L}{M}$ sometimes presented a pathologic value in one or both of the other quotients Thus, the latter were pathologically increased in five cases with a normal $\frac{L}{M}$ quotient The combined use of the three quotients will therefore demonstrate the presence of a pathologically increased neurocranium in 92 7 % of cases Using the cranial index $\frac{L+H+W}{M}$ the corresponding result will be 90 %

In the seven cases with posterior fossa tumour, the mean value of the cranial index was 58 1 Three of the cases presented values within normal limits

Subdural haematoma There were 20 roentgenologically demonstrated and operatively verified cases of subdural haematoma Only five of the cases had an index within normal limits Three of these five cases had had needle puncture

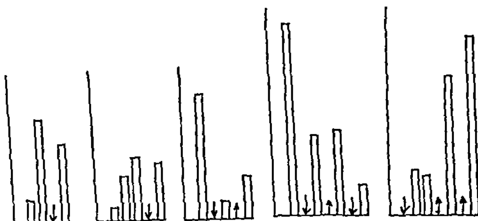


Fig 3 Repeat examinat ons performed n a p tient with hyd ocephalus The C index varied with f nction g (↓) and non functioning (↑) Sp tz Holter shunt.

There were five cases with a probable increase in head size One of these had an increased index and encephalography disclosed central and cortical atrophy Encephalography had also been performed in three of the cases with a normal index one had signs of cortical atrophy only and two had central and cortical atrophy

In the 24 cases of retarded development an index above 56 was noted in only four while the corresponding figure for cases of seizures (epilepsy) was twenty seven out of 67 cases Encephalography in the former group demonstrated central atrophy in one cortical atrophy in one and both types of atrophy in two of the four cases with an abnormal index In the 20 cases with a normal index encephalography had been performed in fourteen and twelve of these had atrophy mainly of the central type

The C index was pathologically increased in 27 of the cases with seizures Eleven of these examined with encephalography showed central atrophy as the most frequent finding This type of atrophy was also most frequently seen in nine pathologic encephalograms from cases with a normal index

The cases collected under the heading miscellaneous included 25 cases, five of which had an increased index Encephalography had been performed in twenty one cases with abnormal findings in twel e cases

Of the 11 cases with myelo- or meningocele nine had a normal and two an increased C index Encephalography had not been carried out in these two cases and hydrocephalus cannot be excluded

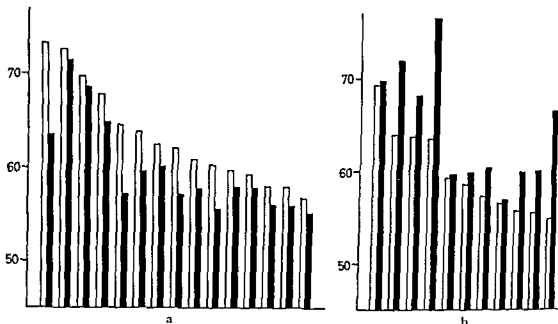


Fig 2 Indices before and after shunt operations in cases of hydrocephalus when the shunts function well (a) and in non functioning shunts (b)

On the other hand, in the twelve cases without increased cranial index two had instead values below the lower normal limits In nine of these twelve cases encephalography had been performed with abnormal findings in all

Cranial index related to indication for examination Excluding cases with verified hydrocephalus, subdural haematoma and cranial maldevelopment, the remaining cases were grouped according to the indication for examination Cases with only routine skull examinations were also included The cases were divided into separate groups as seen in Table 2 One group included twenty one cases of trauma examined to exclude fracture Five cases were examined to exclude increasing head size Retarded development was the main clinical feature in twenty four, and seizures in sixty seven cases Twenty five cases had a variety of symptoms and were included under the heading 'miscellaneous while eleven cases had a myelo or meningocele in various locations Cases with the same diagnosis but with concomitant verified hydrocephalus were placed in the group of hydrocephalus cases The abnormal encephalographic findings particularly considered were cortical and central atrophy

An increased index was evident in five of the 21 cases examined for cranial trauma, in two of these five, encephalography had been performed and had revealed cortical and central atrophy

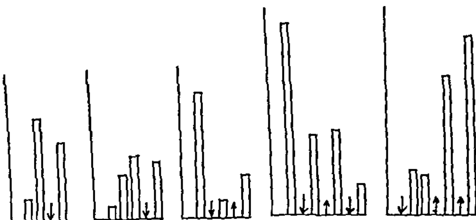


Fig 3 Repeat examinations performed in a patient with hydrocephalus The C index varied with functioning (↓) and non functioning (↑) Spitz Holter shunt

There were five cases with a probable increase in head size One of these had an increased index and encephalography disclosed central and cortical atrophy Encephalography had also been performed in three of the cases with a normal index one had signs of cortical atrophy only and two had central and cortical atrophy

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Index and operative treatment The majority of the cases with hydrocephalus, subdural haematoma or tumour were roentgenologically examined also after operative treatment and the cranial index was determined The hydrocephalic cases were treated with a Spitz Holter ventriculo atrial shunt or a Torkildsen shunt A few cases had a ventriculo pleural or ventriculo abdominal shunt It was found that the cranial index varied in relation to the functioning capacity of the shunt Thus, a decrease of the index regularly followed a well functioning shunt (Fig 2a) and an increase was connected with a badly or non functioning shunt (Fig 2b)

Five examples of cases in which the index was determined repeatedly are given in Fig 3 It may be seen that the index changed depending upon the functioning state of the shunt A similar variation in the cranial index was also noted in cases operated upon for subdural haematoma or intracranial tumour

Discussion

The size and shape of the neurocranium is determined to a large extent by the neural mass, i e the brain and the cerebrospinal fluid As long as the sutures are not closed, any changes in the volume of either of these two components is reflected in the size of the head The expanding capacity of the bony skull is effective up to about 8 years of age Normally the head size, estimated by the circumference, increases most rapidly during the first three months of life The increase continues less rapidly until the age of 12 months, and by the first birthday the postnatal growth is half complete From then on, the growth is slower so that the increase in size runs a more even course and is 90 % complete by the sixth birthday

There is practically no data available on the growth and development of the face in early childhood Observations in older age groups indicate that facial growth in general follows the pattern of the entire body but is most similar to the neural mode (KROGMAN 1910 and SCAMMON et coll 1930) These statements are based upon experience from research work by orthodontists Because of their specific problems, their investigations have been mainly directed towards determining angles and measurements on the face when seen in profile Little is known about growth and measurements on the face in the transverse direction The face is generally not included in routine lateral skull films The experience of the orthodontists cannot therefore be used for the present purpose

Part of the face is however usually visible in frontal films of the skull The two necks of the mandible are generally easily defined and may be used as

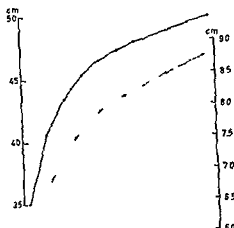


Fig 4 Increase in head size (full line) measured as the largest circumference and in distance as related to age between the two necks of the mandible (broken line)

landmarks for measurements An additional advantage of using these structures for measurement is the fact that they can be expected to follow the growth of the cranial base a part generally not affected by any change in the intracranial content For the present study it was of importance to know the relation of the distance between the two rami mandibulae to age Since it has been shown that the size of the face is independent of the neural growth in pathologic intracranial conditions (YOUNG 1959), the whole material could be used The medial aspects of the neck of the mandible at their thinnest portion, were used as landmarks The transverse distance was measured and was found to increase uniformly up to the age of 7 years The measurements were also plotted by age in comparison to the growth of the head in normal children measured by the largest circumference It may be seen in *Fig 4* that a rough similarity exists between the increase in the mandibular measurement and the increase in the circumference of the skull up to the age of 3 years Further studies of this correlation for patients between 3 and 8 years are in progress

The fact just mentioned constitutes the basis for the new indices The most accurate of these is the quotient $\frac{L}{M}$ which demonstrates an increase in cranial size with 83 % accuracy Investigations concerning the relation between the size of the ventricular system and the size of the skull are normally founded upon the transverse width of the skull The present study has disclosed that the relation between the transverse diameters (W) and (M) is actually the least reliable

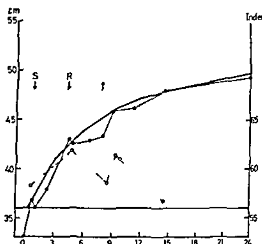


Fig 5 Variations in the C index in a case of hydrocephalus After the first operation (S) the shunt did not function properly and the circumference as well as the index increased Re operation was performed (R) With a well functioning shunt the index decreased and there was a slow increase in the circumference Both increased temporarily after removal of the shunt (A) Later there was no further increase in hydrocephalus and the index decreased to normal value

Transverse diameters should therefore be avoided in all studies on the relation between cranial size and cranial content It is however important to stress that the combined use of the three quotients $\frac{L}{M}$ $\frac{H}{M}$ and $\frac{W}{M}$ will produce still higher accuracy than $\frac{I}{M}$ alone The accuracy is of the same order of magnitude as that obtained with the formula $\frac{L+W+H}{M}$ or for the cranial index It may be that the results of the studies now in progress in patients between 3 and 8 years will necessitate a slight correction of the values of the indices in these age groups When starting the present study, a *volumetric index as estimated by* $L \times H \times W$ was tried The values obtained, when related to M, revealed wide variations and were distributed within wide limits They therefore could not be used

Hydrocephalus is generally defined as ventricular dilatation combined with previous or actually increased intracranial pressure and consequently should lead to an increase in the size of the neurocranium An increased C index was also noted in 70 out of 77 cases with verified hydrocephalus As could be expected, the non communicating type had a higher index than the communicating It is however well known from clinical experience (GRANHOLM) that marked hydrocephalus may exist without an enlarged neurocranium This was the case in seven of the present cases, five of which later had a rapid increase in head size, however, with an increasing index

The findings in cases of subdural haematoma are of particular importance

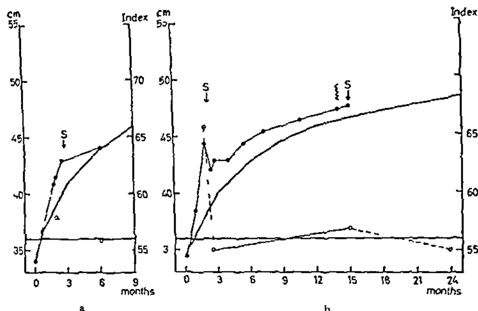


Fig 6 *Variation in the C ndex in cases of hydrocephalus a) After ventriculo-atrial shunt operation* (S) the cranial index dec eased (broken line) and the circumference of the head became normal (full line) b) After the first ope at on the ind x rapidly became normal The shunt d d not funct on after 12 months and the index ncreased After anothe shunt operation the index again became *normal*

The growing employment of transillumination as a diagnostic aid has increased the number of children referred for examination of the skull The *presence* or absence of local deformation thinning of bone asymmetry of the skull or calcification may confirm the clinical diagnosis and lead to more extensive *roentgenologic examinations* This study has indicated that even a small haematoma or hygroma may cause enlargement of the neurocranium Thus an index above 56 was evident in 15 out of 20 cases with operatively verified subdural haematoma The use of the index therefore seems to be of diagnostic value in strengthening the clinical suspicion of a subdural haematoma and the indication for more specialized roentgen *examinations A more* detailed analysis of this group of cases will be published separately

Except hydrocephalus subdural haematoma and tumour the encephalo grams disclosed atrophy of varying degrees in a large number of cases The diagnosis is difficult especially in children (MULLER 1938 MELCHIOR 1961), as there are no generally accepted or set diagnostic criteria *The diagnosis of*

central atrophy was made in this study whenever ventricular dilatation was present without the subsequent presence of occlusion or stenosis of the ventricular system or without signs of subarachnoid block. The ventricular size has been estimated as the ratio between the greatest width of the anterior horn and the greatest transverse distance to the inner table of the skull from the septum pellucidum (GOLLNITZ 1951). The width of the third ventricle was also measured. In accordance with the figures given by SALOMONSEN et coll. (1957), SKATVEDT (1958), SKATVEDT et coll. (1959) and MELCHIOR (1961), 6 mm was considered a normal anterior width. A value of more than 8 mm was definitely pathologic. The amount of cortical air was further assessed, a difficult procedure in children. ZELLWEGER et coll. (1951) and SCHÄFER (1960) stated that the cortical sulci may be radiologically wide in children with anatomically normal brains, and because of this exact measurements were avoided. The finding of one or more broad sulci, situated in the same area in more than one film, has been considered necessary for the diagnosis.

As shown in Table 1, the cranial index was at the lower border of the normal in cases with central atrophy. The difference between the mean values for cases with a normal index and those with an increased index was most evident when ventricular dilatation was registered. This means that in some of the cases the dilatation diagnosed as atrophy was in reality caused by hydrocephalus.

The use of the C index will apparently not be of diagnostic importance for a differentiation between various types of atrophy. It may help in suggesting whether ventricular dilatation is due to central atrophy or to hydrocephalus, however.

Retarded development and seizures were common indications for radiologic examination. An increased index was noted in only four of 24 cases with retarded development, as compared with twenty-seven out of 67 cases with seizures. Some degree of ventricular dilatation was found in three of the 4 cases with high index and retarded development, and in nine of the 11 cases with high index and seizures. Corresponding figures in cases examined with encephalography with a normal index were nine out of 12 cases, and nine out of 9 cases, in the respective groups. The figures seem to indicate that the ventricular dilatation observed in cases with a normal index is different from the one present in cases with a high index.

The use of indices before and after operation has been found to be of particular value. This has been most evident in shunt operated cases with hydrocephalus as well as in cases operated upon for subdural hygroma. The functioning capacity of the shunt in the former is mirrored in the variation of the indices, as shown in Figs. 5 and 6. Successful treatment in cases of subdural

hygroma leads to a decrease in the index A postoperative index of the same magnitude as before the operation or an increasing value, means that a new hygroma is developing

Conclusion

The distance between the two necks of the mandible (M) increases roughly parallel with the skull size up to the age of 3 years It then increases slowly and steadily up to the age of 8 years

Indices based upon the relationship of this distance (M) to the greatest length (L) width (W) and/or height (H) of the neurocranium have proved to be clinically useful and of diagnostic importance All measurements may be made on routine skull films and no special projection is needed

Different ratios of $\frac{L}{M}$ $\frac{H}{M}$ $\frac{W}{M}$ or $\frac{L+H+W}{M}$ (C index) may be used

The ratio $\frac{L}{M}$ is the most useful for practical purposes and will demonstrate *an increase in* head size in 83 % of cases of hydrocephalus $\frac{W}{M}$ is the least reliable ratio This observation is of particular significance *as in most studies* of the relation between cranial size and ventricular size measurement of the largest *transverse* diameter has been used The combined use of $\frac{L}{M}$ $\frac{W}{M}$ and $\frac{H}{M}$ will increase the accuracy of diagnosis up to 93 % By *using* a summation of L + W + H divided by M i e the C index, a percentage of 90 may be *reached*

The C index has mainly been used in the present study *and has proved to* be of practical value not only in the diagnosis of hydrocephalus but also in the diagnosis of subdural hygroma from routine roentgen *films of the skull* The index has *also been employed* for determining pathologic changes in the size of the neurocranium *in cases of atrophy* It seems as if what has been considered to be central *atrophy according to the* general conception in many cases should have been a sign of mild hydrocephalus

The size of the head has also been related to the *dominant* clinical features seizures and retarded developmen being the most *common* Encephalography disclosed the presence of *ventricular dilatation* in both these groups A pathologically *increased* index was more often apparent in cases of *epileptic* fits

The index has also proved to be of *definite value* in the roentgenologic evaluation of operative *results in cases* of hydrocephalus and subdural haematoma

SUMMARY

A new index for evaluating the cranial size in children is described This is based upon the relationship of the distance between the two necks of the mandible and the greatest length width and height of the neurocranium obtained in routine films The clinical value of the procedure particularly in *hydrocephalus* is discussed

ZUSAMMENFASSUNG

Ein neuer Quotient zur Bestimmung der Grosse des kindlichen Schadels wird angegeben Dieser wird darauf basiert dass man durch Messungen auf gewohnlichen Rontgenfilmen den Abstand zwischen den zwei Colli mandibulae und der grossten Lange Breite und *Hohe des Schadels in Verhaltnis stellt Die* klinische Anwendbarkeit der *Methode, besonders* in Fallen von Hydrocephalus wird hervorgehoben

RÉSUMÉ

Description d un nouvel indice destiné a juger les dimensions du crane chez l enfant *Il est* basé sur le rapport entre la distance qui sépare les cols des condyles de la mandibule et la plus grande longueur largeur et hauteur du crane mesurées sur des radiographiques simples *L auteur examine l intérêt clinique de cette méthode en particulier dans l hydrocéphalie*

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FROM THE DEPARTMENT OF DIAGNOSTIC RADIOLOGY (DIRECTOR PROF F KNUTSSON) OF THE UNIVERSITY HOSPITAL, UPSALA, SWEDEN

ELECTROCARDIOGRAMS ON CAROTID ANGIOGRAPHY AFTER PUNCTURE OF THE CAROTID SINUS

by

HERMAN LODIN

The carotid sinus reflex, i e fall in blood pressure and bradycardia, can be induced both by external massage of the carotid region and by compression, and may also occur, although more seldom, on puncture of the carotid artery near its bifurcation Serious complications, including death, both in the so called clinical compression test and in manipulations of the artery during operation have been reported For this reason, among others, it has been recommended that puncture of the sinus region should be avoided in carotid angiography, and that in certain cases of sinus sensitivity the sinus should be blocked by local anaesthesia before the puncture Carotid angiographies are performed at some centres without any checking of the needle position, and without simultaneous ECG recording Little is known, therefore of the events following sinus puncture and contrast injection A series of carotid angiographies, performed in our roentgenologic department, were therefore analysed, and all cases of puncture and contrast injection in the sinus region were studied with special reference to the occurrence of ECG changes

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Table 1

Electrocardiographic reactions on contrast injection after puncture of the carotid sinus in relation to sex and age distribution

ECG changes	N (46)	Males (24)	Females (22)	40 years and over (39)	< 40 years (7)
No change	12	10	2	10	2
Bradycardia	24	10	14	20	4
Tachycardia	7	4	3	6	1
Indefinite slight changes	3	—	3	3	—

Material and Method The material comprised 46 patients the sex and age distributions of whom are given in Table 1

Carotid puncture was performed after only very localized intradermal anaesthesia The position of the needle was checked by means of a film over the puncture site For this the injection was given by hand but otherwise an automatic pressure syringe was used to inject about 6 ml Urografin 60 % At least four injections were given to each patient ECG (lead 2) was recorded before and in a few patients during the puncture and in all patients during as well as 20 to 30 seconds after the contrast medium injections With a few exceptions all the patients were premedicated with 1 ml morphine scopolamine

Sinus puncture means both puncture directly into the bifurcation itself and puncture into the immediate vicinity of the bifurcation i e within one centimetre from it ECG changes were reported as bradycardia tachycardia (i e alterations in heart rate exceeding 10 %) and non specific changes i e minor changes with no special tendency

Results

No changes were observed in the few patients in whom the ECG was recorded during the actual puncture

About half the number of patients investigated reacted with bradycardia during the injection (Table 1) usually followed by tachycardia No ECG changes were noted in about 25 % of the patients while seven of the 46 patients had tachycardia and three reacted with an uncharacteristic rhythm disturbance e g in one injection a slight degree of bradycardia in another mild tachycardia The women displayed a greater tendency to respond with brady

Table 2

Electrocardiographic changes observed in 12 patients examined with angiography both after sinus puncture and low common carotid puncture

ECG sinus puncture N = (12)		ECG changes on carotid puncture			
		No change	Bradycardia	Tachycardia	Indefinite slight changes
No change	1	1			
Bradycardia	8	3	5		
Tachycardia	2			1	1
Indefinite slight changes	1	1			

cardia than men. The age factor was of no influence on the type of ECG reaction.

Twelve of the 16 patients also underwent carotid angiography after low puncture of the common carotid artery. The results of a comparison between the ECG changes observed with the sinus puncture and those recorded with the low carotid puncture are given in Table 2. The recordings in the two angiographies were in agreement in seven of the above mentioned twelve patients while different reactions were observed in the remaining five. The tendency in these differences was towards a reduction of the bradycardia effect in ordinary low carotid injection, with the ECG either unchanged or exhibiting an atypical rhythm disturbance.

In Table 3, a comparison is made with the ECG changes in a larger series,

Table 3

Electrocardiographic observations in 150 patients examined with angiography after low common carotid or internal carotid puncture and in 46 patients investigated after puncture of the carotid sinus

ECG changes	Sinus puncture	Carotid puncture
No change	26	41
Bradycardia	52	31
Tachycardia	15	17
Indefinite slight changes	7	11

comprising 150 patients examined after puncture of the internal or the common carotid artery (LODIN & OTTANDER) This comparison indicates that on injection after sinus puncture there is a considerably higher frequency of bradycardia and that the number of patients with an unchanged ECG is smaller than after an ordinary carotid puncture

The bradycardia observed with these sinus injections was of the same order of magnitude as with injections into the internal and common carotid arteries Only one patient had much bradycardia but no asystole (> 2 seconds between the ventricular contractions) No changes apart from rhythm disturbances were recorded

None of the 46 patients had clinical signs of a fall in blood pressure or other circulatory disturbances in connection with the examination or the puncture

Discussion

The main effect of contrast medium injection into the sinus region is a tendency to bradycardia of a moderate degree The comparison with the larger series of carotid angiographies suggests that this effect is largely provoked locally in the sinus by the stimulation of the baroceptors by the automatic contrast injection

It is evident on the other hand that the reaction is very moderate and that puncture of the sinus region with subsequent injection is not comparable with clinical compression tests HEIDBORN & MCNAMARA (1956) observed 9 cases of asystole among 40 healthy subjects at a compression test of 30 seconds Compression of the right sinus region gave the highest frequency of reactions The bradycardia in the present series was distributed equally between the right and left sided injections In contrast to compression the needle itself may cause a punctate and transient stimulation of the sinus stimulation of the baroceptors provoked by the injection is inconstant and when it does occur it is only of moderate degree Only one of 46 patients had marked bradycardia on contrast injection and no asystole was recorded

The results suggest that the risks connected with sinus puncture appear to be overrated Puncture of this region should be avoided for two reasons however (1) puncture followed by contrast injection provokes ECG changes especially bradycardia to a greater extent than injection into the internal or the common carotid artery and thus influences to a greater degree the circulation time studied with an angiographic technique (2) the mixing of contrast medium and blood may be inadequate when both the internal and external carotid arteries are to be examined with the same injection amount

SUMMARY

A series of 16 angiographies after puncture of the carotid sinus displayed ECG changes to a greater extent than a series in which the injection was given into the internal or the common carotid artery. Moderate bradycardia was observed in half the number of patients.

ZUSAMMENFASSUNG

Es wurde in 46 Fällen festgestellt, dass elektrokardiographische Veränderungen häufiger bei Angiographie durch Kontrastmittelinjektion in den Sinus caroticus auftreten als nach Einspritzung in die Carotis interna oder communis. Mässige Bradykardie wurde in der Hälfte der Fälle observiert.

RÉSUMÉ

Une série de 16 angiographies par ponction dans le sinus carotidien a présenté des modifications ECG plus nombreuses qu'une série dans laquelle l'injection a été faite dans la carotide interne ou la carotide primitive. On a constaté une bradycardie modérée chez la moitié de ces sujets.

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FROM THE DEPARTMENT OF DIAGNOSTIC RADIOLOGY (DIRECTOR PROF F KNUTSSON) UNIVERSITY HOSPITAL UPSALA SWEDEN

ELECTROCARDIOGRAMS ON VERTEBRAL ANGIOGRAPHY

by

HERMAN LODIN

The author has found only a single report in the literature on ECG changes recorded at vertebral angiography GREITZ (1956) observed that injection of contrast medium into the vertebral artery resulted in an increase in heart rate and rise in blood pressure The ECG changes and blood pressure increase were not preceded by bradycardia or a fall in blood pressure This observation however appears to refer to only one injection with the medium Triurol (sodium acetrizoate) Greater interest has been paid on the other hand to ECG recordings at carotid angiography (GREITZ 1956 EPSTEIN et coll 1959 GREITZ & WEISS 1959 KLINGLER 1960 LODIN & OTTANDER 1967) The results of these investigations performed with different contrast media do not appear to be directly applicable to the conditions in vertebral angiography GREITZ s work suggests that a single injection into the vertebral arterial system may produce different effects on the systemic circulation than one made into the carotid arterial system where bradycardia predominates

The ECG changes observed in a series of vertebral angiographies performed with Urografin as contrast medium are reported in this paper

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Table 1

Electrocardiographic changes observed on vertebral angiography and grouped according to sex, age and examination technique

ECG changes	N (60)	Males (33)	Females (27)	40 years and over (39)	<40 years (21)	Catheter (39)	Puncture (21)	Manual injection (47)	Pressure injection (13)
No change	15	7	8	10	5	7	8	11	4
Bradycardia	13	5	8	8	5	11	2	11	2
Tachycardia	29	19	10	19	10	19	10	22	7
Indefinite slight changes	3	2	1	2	1	2	1	3	

Material and Method. The material comprised 60 patients on whom 66 examinations were performed. Five patients underwent both right- and left-sided vertebral angiography, and one was examined twice on the same side.

A catheter was used in 39 of the patients, and it was generally advanced via the femoral artery, with the tip being placed in the proximal part of the left vertebral artery. Occasionally, the catheter was introduced via the right axillary artery and the tip located in or immediately in front of the origin of the right vertebral artery. Puncture of the vertebral artery was performed in 21 cases. In the majority of these cases, as well as in all the cases in which a catheter was used, no general anaesthesia was given. Local anaesthesia was however given in all the puncture cases, in the usual manner downwards towards the transverse processes of the cervical vertebrae, and the position of the needle was checked by a film over the puncture site.

An effective dose of 5 to 6 ml Urografin 60 % was injected manually in 47 patients, and by means of an automatic pressure syringe in 13 patients. At least three injections were given at each examination, i.e. in all about 200 injections were made.

ECG (lead 2) was recorded both before and after the puncture, or the introduction of the catheter, as well as during, and 20 to 30 sec after, the injections. In about 20 of the patients the ECG recordings were made with the film changer in operation, but without simultaneous contrast medium injection, in order to find out whether the noise of the film changer during actual exposures might provoke an alteration in cardiac action towards tachycardia in anxious patients. Blind injections with physiologic saline were sometimes given. The ECG changes observed were classified as bradycardia, tachycardia (i.e. alterations in heart rate exceeding 10 %) and non-specific slight changes, i.e. slight rhythm disturbances without any definite tendency.

Table 2

Electrocardiographic changes in 33 patients examined both with vertebral and carotid angiography

ECG changes at vertebral angiography N = (33)		ECG changes observed at carotid angiography			
		No change	Bradycardia	Tachycardia	Indefinite slight changes
No change	9	6	3		
Bradycardia	8	2	4	1	1
Tachycardia	16	4	4	6	2
Indefinite slight changes	—				

In 33 of the 60 patients carotid angiography was also performed This was done by the customary technique with direct puncture generally of the common carotid artery About 6 ml Urografin 60 % were injected with an automatic pressure syringe A film was exposed over the puncture site to check the position of the needle

Both the vertebral and carotid angiographies were technically satisfactory, i e it was confirmed that the needle was in the correct position before the injections were given The posterior cerebral arteries were filled in all the vertebral angiographies With a few exceptions all the patients received the same form of premedication (1 ml morphine scopolamine)

Results

No ECG changes occurred with the saline injections or when the film changer was in operation without one contrast medium injection being performed at the same time

ECG changes of the tachycardia type were present in about half the number of patients examined (Table 1) while bradycardia generally followed by transient tachycardia was recorded in just under a quarter of the patients The ECG was unaffected in a quarter of the patients In three patients there were very slight changes and no specific tendencies were noted in the different series of injections An isolated extrasystole and transient depressed S T interval were noted in one bradycardia patient Otherwise, all the ECG changes were rhythm disturbances The ECG displayed the same tendency at all the injections in all the patients except three In two of these the changes recorded became increasingly less marked in the last series of injections and in the third patient in whom the first six injections resulted in bradycardia slight tachycardia occurred in the seventh series

Table 3

Electrocardiographic changes observed at 150 carotid angiographies and 60 vertebral angiographies

ECG changes	Carotid angiography %	Vertebral angiography %
No change	41	25
Bradycardia	31	22
Tachycardia	17	48
Indefinite slight changes	11	5

The ECG changes were the same in all the series of injections in the five patients in whom both right- and left sided vertebral angiographies were performed In the sixth patient, in whom two vertebral angiographies were performed on the same side on different occasions, the reactions were the same

Carotid angiography was performed on 33 of the 60 patients The ECG changes observed in the vertebral and carotid angiographies are compared in Table 2, which indicates that while the ECG reaction was the same in the two types of examinations in about half the number of patients it differed in the remainder Among 9 patients, in whom the ECG was unchanged at vertebral angiography, six had the same result on carotid angiography, while the other three had bradycardia Of 8 patients with bradycardia on vertebral angiography, four displayed the same reaction on carotid angiography while one had tachycardia, one an uncharacteristic rhythm disturbance and two an unaffected ECG Of 16 patients, finally, with tachycardia on vertebral angiography, six were found to have the same tendency to tachycardia on carotid angiography, while four had no changes at all, four had bradycardia, and two an atypical rhythm disturbance

Discussion

It is evident from Table 1 that neither the age nor the examination technique had any influence on the results obtained The men had a greater tendency to respond with tachycardia than the women

It is apparent from Table 2 that Urografin may induce different changes in the same patient, depending on which cerebral artery is injected

In Table 3 a comparison is made between the present series of vertebral angiographies and a series of 150 carotid angiographies (LODIN & OTTANDER) The number of unchanged ECG, and those exhibiting bradycardia are greater in the carotid series while tachycardia is considerably more frequent among the vertebral angiographies

GREITZ from clinical and radiologic observations as well as LINDGREN, and LINDGREN & TORNELL from animal experiments believe that bradycardia is provoked via the central nervous pathways These authors consider that the contrast medium primarily induces a vagal effect and that the baroceptors in the carotid sinus are of no importance in the bradycardia induced by carotid angiography However on contrast medium injection after puncture of the carotid sinus, the frequency of bradycardia increased (LODIN) which would seem to indicate that in such cases the baroceptors in the carotid sinus take part in the bradycardia reaction Tachycardia on the other hand might result from stimulation of the chemoceptors in the carotid body but since tachycardia may occur also on injection above the bifurcation it is more probable that this effect as well may have a central origin

The results now presented strongly support the theory of a central influence on the rhythm disturbances since both bradycardia and tachycardia have been observed to occur in connection with vertebral angiography It is interesting however that tachycardia is much more frequent than bradycardia at vertebral angiography and that the number of unchanged ECG is smaller than in the carotid series It seems reasonable to find an explanation in the distribution of the contrast medium It becomes apparent when analyzing the contrast filling of the posterior cerebral artery in the carotid series that this artery is filled in only 20 % of the bradycardia patients but in 50 % of the tachycardia patients It may be justified to assume that the tachycardia reaction is provoked mainly from a vasomotor centre in the medulla oblongata supplied from the basilar artery system including the posterior cerebral arteries The bradycardia effect on the other hand is essentially elicited higher up in the brain stem where the blood supply to a greater extent is derived from branches of the internal carotid artery The sensitiveness of the medulla oblongata to the contrast medium may be indicated by the reduced number of unchanged ECG in comparison with the carotid series

The various reactions may thus be explained equally well by the different distribution regions of the carotid and vertebral vessels as by individual variations in the blood supply of the vasomotor centres Both different ECG reactions in the same patient depending on the injection artery and different effects in different patients with the same type of injection may thus be obtained

Conclusion

The distribution of the electrocardiographic changes in vertebral angiography differs from that in carotid angiography Tachycardia is considerably more frequent than bradycardia and the unaffected ECG are less frequent

On evaluating the effect of the contrast medium in cerebral angiography the conditions prevailing in both carotid and vertebral angiographies must be taken into the consideration Results obtained in animal experiments are of course valuable but cannot often without reservation be transformed to human subjects This must be stressed in particular where the problems concern the central nervous system since most experimental animals have a cerebral vascular distribution that is very different from that of man

Substances other than contrast media may of course produce different central reactions depending on the method of administration The results presented in this paper may open up a new field for the radiologist who is interested in selective studies of different active substances We have at present an investigation in progress in our department on the effect of bradykinin in connection with carotid and vertebral angiographies (ERIKSON & LODIN)

SUMMARY

A series of 60 patients were subjected to vertebral angiography with simultaneous ECG recording Carotid angiography as well was performed in 33 of these patients The changes observed in the ECG are discussed Different rhythm changes were recorded in half the number of patients who underwent carotid angiography

ZUSAMMENFASSUNG

An einer Serie von 60 Patienten wurde vertebrale Angiographie mit gleichzeitigen elektro kardiographischen Studien vorgenommen Carotisangiographie wurde in 33 dieser Falle ebenfalls ausgefuhrt Verschiedene Formen von Rhythmusveranderungen konnten bei der Halfte der Patienten an denen Carotisangiographie vorgenommen wurde festgestellt werden

RÉSUMÉ

Une série de 60 malades ont subi une angiographie vertébrale avec enregistrement ECG simultané Une angiographie carotidienne a aussi été pratiquée dans 33 de ces cas L auteur examine les modifications ECG On a trouvé différentes modifications du rhythme chez la moitié des malades qui ont subi une angiographie carotidienne

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TEMPORAL ARTERIAL GEODESICS

II Effects of masses deep to the temporal lobe

by

HAROLD Z LEHRER

An experienced neuropathologist in examining the brain prior to sectioning will often be able to predict some deep pathologic process from the pattern of the cerebral gyri and sulci at the surface Equivalent information about the existence of a deep lesion may be derived by the radiologist from the configuration of the surface arteries as seen on cerebral angiography It has been suggested in earlier papers (LEHRER 1967) that the displacement of the superficial arteries by cerebral masses may be divided into two main types direct and indirect displacements

Direct displacements imply that the arteries are generally considerably curved, running parallel with or outlining the borders of the lesion Displacements of this type occur in the neighborhood of a well defined mass such as a typical meningioma

However the great majority of intrinsic cerebral tumors, being less discrete and situated away from the surface, are associated with indirect displacements of the surface arteries these are produced secondary to a volume increase The arteries lose their normal redundancy corresponding to smoothing out of the normally wrinkled gyri and sulci As the arteries straighten they tend to assume paths of

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Fig 1 Large sphenoid wing meningioma located inferomedial to the temporal lobe The main middle cerebral arteries within the insula are elevated and curved The surface temporal branches are straightened into approximately parallel geodesics

minimum length over the cerebral surface The resultant configurations which the present author has termed arterial geodesics approximate areas of great circles over the cerebral convexities but over the flatter less spherical surface of the temporal lobe they tend to approach the nearly parallel geodesics of an ellipsoid

Over the cerebral convexities the presence of arterial geodesics reliably reflects an intrinsic hemispheric volume expansion With respect to the temporal lobe however because of its relatively superficial anatomic site a volume expansion deep in relation to the lobe causing arterial geodesics over its outer surface, can be either extrinsic or intrinsic

Medial extrinsic tumors Large inferomedial extrinsic lesions such as parasellar and medial sphenoid wing meningiomas (see Fig 1) produce displacements of the major temporal arteries which may be very much like those seen with intrinsic temporal masses (CHASE & TAVERAS 1963) The similarity of these arterial displacements is understandable when considering that the tumor tends to push the entire temporal lobe upwards and outwards but is constrained in this action by the dura and the inner table of the temporal bone The outer surface of the temporal lobe limited by the contours of the temporal bone may thus become flattened secondary to a large deep extrinsic tumor, much as it would by a volume increase caused by an intrinsic lesion of the temporal lobe The main middle cerebral arteries within the insula which undergo a less restrained displacement of the direct type thus tend to be curved and elevated

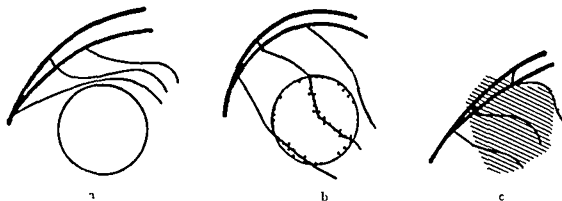


Fig 2 Configurations of the middle cerebral artery with various tumors a) In the presence of a *superficial extrinsic tumor as for example a lateral sphenoid wing meningioma* the superficial temporal arteries are directly displaced around the circumference of the lesion along the temporal surface In this diagrammatic representation the main insular branches of the middle cerebral artery are indicated with heavier lines b) A deep inferomedial extrinsic tumor causes the superficial arteries to straighten and appear as temporal lobe geodesics The tendency toward a spherical outward displacement of the temporal lobe is constrained by the dura and the inner table of the temporal bone resulting in an ellipsoid surface Direct displacement of the main insular branches of the middle cerebral artery with elevation and increased curvature c) *An intrinsic tumor deep to the insula will cause the superficial temporal arteries* to straighten corresponding to flattened sulci The main sylvian branches may be elevated to shorten their path over the expanded inner surface of the insula but they are not sharply curved



Fig 3 Intracerebral hemorrhage a) A p view The insula is displaced outwards and expanded but not rotated b) Lateral view Originally tortuous vessels over the surface of the temporal lobe are straightened and approximately parallel In this case the main insular branches are only slightly elevated

in the presence of such tumors (Fig 2) Direct displacement of the anterior choroid artery is an important further guide to the presence of an extrinsic lesion (CHASE & TAVERAS 1963)

Intracerebral masses deep to the insula A large intrinsic mass deep to the insula an intracerebral hemorrhage for example (Fig 3) may also lead to a flattening of the outer surface of the temporal lobe and consequently tends to cause arterial geodesics to form The main middle cerebral arteries will in such cases be indirectly displaced by the underlying diffuse lesion The arteries may be elevated since they will follow the shortest path (geodesic) along the inner surface of the insula but they will in general not be sharply curved Similar configurations of the middle cerebral artery have been described earlier with thalamic tumors (POTTS & TAVERAS 1963) It would seem that these appearances could be best explained in the same fashion as attempted above rather than by postulating an outward rotation of the insula (TAVERAS & WOOD 1964)

A less extensive deep mass will naturally cause a smoothing out of the temporal lobe surface of lesser degree and then the straightening of the superficial arteries may not be so obvious particularly if the primarily normal course of these vessels in a given patient was more redundant or tortuous than sommonly seen These subtler changes occur rather frequently and can often be verified or at least suggested by a comparison with the less straightened arteries of the contralateral temporal lobe as obtained in a carotid arteriogram

SUMMARY

Tumors lying deep in the temporal region may because of the anatomic location of the temporal lobe be either extrinsic or intrinsic Large inferomedial extrinsic tumors may produce arterial geodesics resembling those with intrinsic temporal tumors although the main insular branches being directly displaced are usually somewhat more curved Intrinsic cerebral masses deep to the insula cause less marked straightening of the surface arteries as well as geodesic displacement of the main insular branches

ZUSAMMENFASSUNG

Tumoren tief in der temporalen Region sind auf Grund der anatomischen Lage des Schlafenlappens extrinsic oder intrinsic Inferomediale Tumoren die gross und extrinsic sind konnen arterielle geodatische Linien ahnlich wie bei den intrinsic temporalen Tumoren hervorrufen obwohl die wichtigsten insularen Äste die direkt verschoben werden meistens etwas krummer sind Intrinsic Zerebrallasionen die tief in der Insula liegen verursachen weniger markante Ausdehnung der superfiziellen Arterien und eine geodatische Verschiebung der insularen Hauptaste

RÉSUMÉ

En raison de la situation anatomique du lobe *temporal* les tumeurs de la *région temporale* situées en profondeur peuvent être extrinsèques ou intrinsèques. Les grosses tumeurs inféro-internes extrinsèques peuvent donner des images artérielles géodésiques ressemblant à celles des tumeurs temporales intrinsèques bien que les principales artères insulaires étant directement déplacées soient d'habitude un peu plus incurvées. Les masses cérébrales intrinsèques situées en profondeur par rapport à l'insula donnent un étirement moins marqué des artères superficielles et un moindre déplacement géodésique des grosses branches insulaires.

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ROENTGENOLOGIC CHANGES IN OTOSCLEROSIS

by

BENGT LILIEQUIST

The development of modern tomographic techniques has opened up a new field in otologic roentgenology Malformations of the middle and inner ear, luxation of the auditory ossicles and the result of corrective surgery of the tympanic cavity may now with advantage be examined roentgenologically Even the otosclerotic process has become accessible for roentgenologic procedures Along with this alteration in attitude a change of the roentgenologic technique has become necessary The classic projections of the middle ear no longer hold the field as most attention has now moved from the examination of the tympanic cavity and mastoid cells to the walls and contents as well as to the labyrinth capsule A prerequisite for fulfilling this new aim consists of tomography in thin sections with circular semicircular or hypocycloid movements

ZIEDSE DES PLANTES (1932) was one of the first to investigate the possibility of examining the temporal bone by circular tomography MUNTEAN & FINK (1941) further developed the tomographic examination of the ear FREY (1956) and MUNDNICH & FREY (1959) finally worked out the technique of tomography of the temporal bone and the projections used by later investigators are mainly founded upon their investigations The normal anatomy of the middle and inner ear as it appears in these and similar projections has been investigated roentgen

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RÉSUMÉ

En raison de la situation anatomique du lobe temporal, les tumeurs de la région temporale situées en profondeur peuvent être extrinsèques ou intrinsèques. Les grosses tumeurs inféro-internes extrinsèques peuvent donner des images artérielles géodésiques ressemblant à celles des tumeurs temporales intrinsèques, bien que les principales artères insulaires, étant directement déplacées, soient d'habitude un peu plus incurvées. Les masses cérébrales intrinsèques situées en profondeur par rapport à l'insula donnent un étirement moins marqué des artères superficielles et un moindre déplacement géodésique des grosses branches insulaires.

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ZIEDSES DES PLANTES (*1932*) was one of the first to investigate the possibility of examining the temporal bone by circular tomography. MUNTEAN & FINK (1941) further developed the tomographic examination of the ear. FREY (1936) and MÜNDNICH & FREY (1959) finally worked out the technique of tomography of the temporal bone, and the projections used by later investigators are mainly founded upon their investigations. The normal anatomy of the middle and inner ear as it appears in these and similar projections has been investigated *roentgen*

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RÉSUMÉ

En raison de la situation anatomique du lobe temporal, les tumeurs de la région temporale situées en profondeur peuvent être extrinsèques ou intrinsèques. Les grosses tumeurs inféro-internes extrinsèques peuvent donner des images artérielles géodésiques ressemblant à celles des tumeurs temporales intrinsèques, bien que les principales artères insulaires étant directement déplacées soient d'habitude un peu plus incurvées. Les masses cérébrales intrinsèques situées en profondeur par rapport à l'insula donnent un étirement moins marqué des artères superficielles et un moindre déplacement géodésique des grosses branches insulaires.

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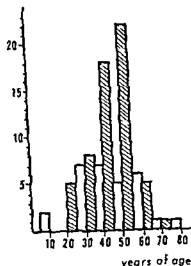


Fig 1 Distribution of otosclerotic ears (hatched columns) in relation to the age of the patients in the material investigated

findings The tomographic examination is suitable as a diagnostic test in questionable cases in the evaluation of type degree and extension of the process in demonstrating possible abnormalities of adjacent structures and in evaluating the postsurgical condition This author also pointed out that the process in active otosclerosis or otospongiosis may be demonstrated as an unsharpness of the bone substance around the oval window causing the opening to appear wider than normal Furthermore he describes the appearance of decalcified areas alone or combined with small sclerotic foci in the labyrinth bone capsule as well as extensive obliterative changes with complete loss of contrast between the capsule and the lumen of the inner ear structures in cochlear otosclerosis According to VALVASSORRI the degree and extent of the otosclerotic process may be distinguished fairly well in tomographic examinations

JENSEN ROVSING & BRUNNER published measurements of the oval window in normal and otosclerotic patients As the normal foot plate of the stapes is too thin to be seen roentgenographically the vestibular window appears as an *opening in the bone walls between the vestibulum* and the tympanic cavity When the foot plate is thickened the oval window can no longer be seen, and a narrowing may be caused by lokal thickening of the rims or walls of the fossula These authors reported the normal height of the oval window to be between 1 and 2 mm The height in otosclerosis was in more than 66 of the patients less than 1 mm in 20 % it measured between 1 and 2 mm and in two of 39 patients the

ologically by JUSTER & LISCHGOLD with cuts of temporal bones CHAUSSE likewise greatly contributed to the roentgenologic examination of the middle ear and proposed suitable projections for investigating the medial and lateral wall of the tympanic cavity and tomographic examinations with Chausse projections

Otosclerosis is a primary disease of unknown etiology of the labyrinth capsule, which sometimes leads to a fixation of the stapes in the vestibular window The diagnosis is mainly based upon the clinical history of progressive deafness, which on audiometric examination consists of a conductive hearing loss, with a gap between impaired air conduction and bone conduction Bone conduction is normal when only the stapedial foot plate is involved but impaired when the cochlea is affected Characteristic otosclerotic foci have been observed histologically in the labyrinth capsule without involvement of the stapes and oval window and without clinical signs of otosclerosis The process is usually present in both ears but may occur in only one ear

The normal substance of the labyrinth capsule, consisting entirely of compact bone, has a unique appearance It therefore normally appears in the roentgen film as dense bone without structure and may thus easily be distingushed from the rest of the temporal bone The otosclerotic process starts in small areas where the compact endosteal bone substance is transformed into vascular osseous tissue with haversian canals These foci may coalesce and extend to large portions of the capsule, the bone substance eventually developing into a denser type of osseous tissue The process usually starts anterior to the oval window and extends to the round window but the whole of the capsule may be involved as may the foot plate of the stapes The local bone substance thickens, with encroachment upon the cochlea as well as on the vestibulum, semicircular canals and the foot plate of the stapes which will be attached to the oval window by bony bridges A narrowing of the fossula of the oval window is caused by a similar thickening of its bony walls

Previous examinations Previous reports on the roentgenologic manifestations of the otosclerotic process mainly deal with diffuse changes in the entire labyrinth capsule although COMPERE (1960) with a conventional roentgenologic technique demonstrated a correlation between localized sclerotic changes in the temporal bone and clinical signs of otosclerosis MUNDNICH originally suggested the possibility of demonstrating with the tomographic technique pathologic changes in otosclerosis adjacent to the oval window The first to report convincing results in otosclerosis with hypocycloid tomography were VALVASSORI (1965) and JENSEN ROVSING & BRUNNER (1966)

VALVASSORI reported the roentgenologic findings in more than 200 patients with otosclerosis examined tomographically The following summarises his

Table 1

Width in mm of the oval window and number of ears in the different groups

	—	(+)	0.5	1.0	1.5	2.0	>2.0	Total
Group 1	43	7	5	15	12	14	6	102
Group 2	3	0	1	0	3	2	0	9
Group 3	4	0	1	7	13	16	0	41

The — in first column indicates that the oval window was not distinguishable and the + in the second column indicates that the window was too small to be measured.

the examined ear but evidence of otosclerosis in the other; group 3, ears without clinical signs of otosclerosis.

The roentgenologic examination was performed with the Mimer which allows semicircular tomography with 1 mm cuts. The magnification was 1.32, focal size 0.6 mm, exposure time 4.0 sec. and kV between 65 and 75. A more detailed description of the Mimer and the technique have been given in articles by Fredzell & Lindgren (1960), Lindgren & Mattsson (1965) and Liliequist (1966).

Only a.p. views have been obtained in this investigation, these being the easiest to produce as well as to repeat. The examinations were also performed in the Chaussé III position and in a few instances in a modified Stenver's position. All the measurements were however obtained from films in the a.p. projection. The whole of the middle and inner ear was examined with tomographic cuts 1 to 2 mm apart, the main attention being directed to the oval window and its surroundings (Fig. 2a).

Results

Vestibular window. The width of the oval window has been measured in a total of 152 ears distributed among the three groups as follows: group 1—102 ears, group 2—9 ears, group 3—41 ears. The results of the measurements are given in Table 1. In *group 1* the oval window was in fifty ears (49.0 %) either not distinguishable or so small that it could not be measured. In twenty ears the oval window was 0.5 to 1.0 mm in width (19.6 %). It was below 1.5 mm in width in seventy ears (68.6 %).

In group 2 the corresponding figures were three ears (33.3 %), one ear (11.1 %) and four ears (44.4 %).

In group 3 the oval window could not be identified or was so small that it could not be measured in four ears (9.8 %). In eight ears (19.5 %) it was



Fig 2 A p views semicircular tomography a) Normal ear cut through vestibulum oval window, lateral semicircular canal and basal turn of cochlea b) Otosclerotic ear the oval window closed

height was 2 5 mm The roentgenologic changes were divided into three groups The smallest change consisted of a narrowed oval window More extensive changes were closure of the oval window as well as increasing sclerosis of the surrounding bones The most striking changes appeared in the walls of the vestibulum and semicircular canals with thickened bone reducing the size of the vestibulum, semicircular canals and the fossula of the oval window These authors could not, however, verify most of the detailed changes described by VALVASSORI but mentioned the possibility of identifying a difference in the extent of the process in the two ears

Material and Methods The present author has tomographically examined 59 patients with clinical signs of otosclerosis in order to investigate the appearances of the otosclerotic process The clinical signs were in ten patients limited to the one ear Altogether 102 ears with otosclerosis were examined In nine of the patients with clinical signs of otosclerosis in one ear, the other ear, which was found to be normal on clinical examination, was examined tomographically Further, twenty-seven patients without clinical signs of otosclerosis were also examined and of these 41 ears were used in the investigation The patients without clinical signs of otosclerosis were investigated because of facial nerve palsy, vertigo, signs of subluxation of the auditory ossicles, and, in a few instances, because of chronic middle ear infection Among the otosclerotic patients, 33 were women and 26 men, and among the normal subjects there were 11 women and 16 men The distribution according to age is given in Fig 1

The material was divided into three groups as follows group 1, ears with clinical signs of otosclerosis, group 2, ears without clinical signs of otosclerosis in

Table 2

Size in mm of the vestibulum and number of ears in the different groups

	2 5	3 0	3 5	4 0	4 5	5 0	5 5	6 0	6 5	7 0	Total
Group 1	2	16	9	42	13	10	0	1	0	1	94
Group 2	0	0	1	7	1	0	0	0	0	0	9
Group 3	0	1	2	26	10	1	0	0	0	0	40

Table 3

Width in mm of the lateral semicircular canal and number of ears in different groups

	3 5	4 0	4 5	5 0	5 5	6 0	6 5	7 0	7 5	8 0	Total
Group 1	1	9	8	29	8	25	4	9	1	1	95
Group 2	0	1	0	4	0	1	1	2	0	0	9
Group 3	0	3	4	16	5	9	1	1	0	0	39

at the level of the oval window The results of such measurements are given in Table 2 Measured in this way there was no difference to be found in the size of the vestibulum for otosclerotic and non otosclerotic ears in this material This is not in agreement with the findings of JENSEN et coll

Width of lateral semicircular canal The lumen of the lateral semicircular canal is usually well shown in tomographic films (Fig 2a) It is however nearly impossible to measure the width of its lumen in such films since it is small in itself and the variations are too small to be registered satisfactorily The present author has preferred to measure the outer dimension of the compact bone substance which surrounds the lateral semicircular canal in the hope that this mass of bone might reflect a thickening of the labyrinth bone sub tance These measurements are easy to perform as the compact bone substance stands out distinctly The results of these measurements are given in Table 3 There seems to be no difference in the width of this bone substance when comparing otosclerotic and non-otosclerotic ears This does not mean that otosclerotic changes may not be found around the lateral semicircular canal but only that they are not reflected in the overall thickness of this bone substance

Thickness of the labyrinth capsule The author like other investigators has also studied the appearances of the capsule It is well known that there are variations in the appearance of the bony labyrinth it may sometimes appear as



Fig. 3. A.p. views semicircular tomography. a) Otosclerosis. The oval window is wider than 2 mm. b) Otosclerosis. Patchy sclerosis in the basal turn of the cochlea.

between 0.5 and 1.0 mm, and in twelve ears (29.2 %) less than 1.5 mm. It was 1.5 mm or larger in twenty nine ears (70.8 %).

The difference in width of the oval window between groups 1 and 3 strongly points to a difference in the appearance of the oval window in otosclerotic and non-otosclerotic ears. The results are in agreement with those obtained by JENSEN, ROVSING & BRUNNER although the variation is not so marked. This can possibly be explained by a difference in technique; JENSEN et coll. employed 0.5 tomographic layers, the difference in the actual investigation being 1 or 2 mm.

An oval window wider than 2 mm was apparent in six otosclerotic patients and in no patient without otosclerosis. This seems to confirm the report by VALVASSORI that an active otosclerotic process may be distinguished by tomographic examination. The same result was reported by JENSEN et coll.

A failure to identify the oval window thus strongly favours an otosclerotic process involving the stapedial foot plate and its surroundings (Fig. 2b). On the other hand, an opening wider than 2 mm has been found only in patients with otosclerosis and is probably a sign of an otospongiotic stage of the process (Fig. 3a).

Size of vestibulum. The pathologic changes caused by otosclerosis are not limited to the bone substance adjacent to the oval window but may reach regions farther away in the surroundings or be found only in the cochlear or vestibular portions of the labyrinth capsule or in the bony walls of the semicircular canals. When the bone substance is thickened the lumen of the labyrinth structures may be narrowed. JENSEN et coll. stated that in late stages the lumen of the vestibulum and lateral semicircular canal are narrowed roentgenologically. The vestibulum appears distinctly in tomographic films (Fig. 2a) and its depth can be measured

Table 2

Size in mm of the vestibulum and number of ears in the different groups

	2 5	3 0	3 5	4 0	4 5	5 0	5 5	6 0	6 5	7 0	Total
Group 1	2	16	9	42	13	10	0	1	0	1	94
Group 2	0	0	1	7	1	0	0	0	0	0	9
Group 3	0	1	2	26	10	1	0	0	0	0	40

Table 3

Width in mm of the lateral semicircular canal and number of ears in different groups

	3 5	4 0	4 5	5 0	5 5	6 0	6 5	7 0	7 5	8 0	Total
Group 1	1	9	8	29	8	25	4	9	1	1	95
Group 2	0	1	0	4	0	1	1	2	0	0	9
Group 3	0	3	4	16	5	9	1	1	0	0	39

at the level of the oval window The results of such measurements are given in Table 2 Measured in this way, there was no difference to be found in the size of the vestibulum for otosclerotic and non otosclerotic ears in this material This is not in agreement with the findings of JENSEN et coll

Width of lateral semicircular canal The lumen of the lateral semicircular canal is usually well shown in tomographic films (Fig 2a) It is however nearly impossible to measure the width of its lumen in such films since it is small in itself and the variations are too small to be registered satisfactorily The present author has preferred to measure the outer dimension of the compact bone substance which surrounds the lateral semicircular canal in the hope that this mass of bone might reflect a thickening of the labyrinth bone substance These measurements are easy to perform as the compact bone substance stands out distinctly The results of these measurements are given in Table 3 There seems to be no difference in the width of this bone substance when comparing otosclerotic and non otosclerotic ears This does not mean that otosclerotic changes may not be found around the lateral semicircular canal but only that they are not reflected in the overall thickness of this bone substance

Thickness of the labyrinth capsule The author, like other investigators has also studied the appearances of the capsule It is well known that there are variations in the appearance of the bony labyrinth it may sometimes appear as

Table 4

Thickness of the labyrinth capsule and number of ears in the different groups

Groups	Labyrinth capsule		Total
	Thick	Normal	
1	47	53	100
2	2	7	9
3	9	32	41

Table 5

Number of ears with local sclerosis in the different groups in relation to the number of ears investigated

Groups	Patchy sclerosis	No sclerosis	Total
1	47	53	100
2	1	8	9
3	4	37	41

a large volume of bone substance and other times as a slender bone capsule These appearances may partly be due to the varying volume of the aerated cells which more or less surround the labyrinth capsule There are however also variations of other type in the appearance of the capsule The results of this grouping of the examinations into a thickened or 'sclerotic labyrinth capsule and a labyrinth of normal appearance is given in Table 4 The difference is small however, and does not permit of a definite differentiation between an otosclerotic and a non otosclerotic temporal bone

Local sclerosis Local sclerotic foci are described as appearing in the basal turn of the cochlea, around the oval window or more rarely in other regions of the labyrinth capsule (VALVASSORI) Patchy sclerosis was sometimes evident in this material, this was either rather extensive or was divided into small areas of apparently sclerosed bone substance ((Fig 3b) These changes were mainly seen in the wall of the basal turn of the cochlea adjacent to the oval window but also appeared for a short distance to the other side of the oval window The number of ears with such changes are recorded in Table 5, they were present in only four patients in group 3 and in one patient in group 2 On the other hand, the patchy sclerosis was apparent in forty seven out of 100 ears with clinical signs of otosclerosis, in two examinations it could not be stated with certainty whether any changes existed or not

Discussion

The nature and etiology of the otosclerotic process is unknown The process is limited to the endosteal bone substance of the labyrinth capsule and histologically includes osteoclastic destruction of the normal endosteal bone, formation of pathologic bone marrow and replacement of the spongiotic bone with a network

of newly formed web like bone rich in cement and poor in fibrils (RUEDI 1963) Both the porotic bone and the newly formed bone may theoretically be identified by roentgenologic pro edures provided the process reaches sufficiently wide areas The spongiotic foci appear as thinner portions and the sclerotic foci as a thickening of the bone with possible narrowing of adjacent formations as the opening of the oval window the cochlea the semicircular canals or the ves tibulum Extensive changes may occur around the cochlea without involvement of the stapes and the window, this has been termed cochlear otosclerosis The roentgenologic appearance of the capsule in such patients has however not been specially examined in the present investigation When the stape is fixed in the oval window or the round window is occluded the patient has clinical signs of impaired hearing with a gap between bone and air conduction In this material all the patients had such a gap and thus belong to the group of fenestral otosclerosis No detailed correlation has been made between the surgical and the roentgenologic findings but in all patients a fixation of the stapes in the oval window was present at operation

Localized thickening of the bone may be identified by tomographic exami nation with semicurcular or hypocycloid movements The regions surrouding the oval window are very suitable for roentgenologic examination as both the oval window and the fossula can be identified as openings in the bone substance, provided suitable projections are chosen It may be stated that narrowing of the oval window or failure to distinguish it in tomographic films strongly suggests involvement of the stapedial foot plate in otosclerosis The failure to demonstrate the opening of the oval window in four of the 41 normal ears may possibly be explained by the fact that tomographic cuts were sometimes taken 2 mm apart instead of 1 mm

Tomographic cuts of the otoslerotic ears were mostly obtained at every milli meter The examination of the non otosclerotic ears was however not always directed to the oval window but to other regions such as the walls of the attic or the ossicles

The roentgenologic appearances of focal sclerotic changes are consistent with the patchy lo alization of the otosclerotic process reported in an overwhelming number of histologic examinations of the temporal bone Focal sclerotic changes identified roentgenologically have previously been reported by VALVASSORI In order to be identified in the roentgen film they must however be extensive and most of the small foci reported histologically cannot be expected to have been visible roentgenographically It is however known that the foci may coalesce and form large regions of pathologic bone often including parts of the cochlea the walls of the interior auditory canal or the regions of the semicircular canals Thickening of bone may occur but large foci may be found histologically without

evidence of increase in volume As the bone substance of the labyrinth capsule normally consists of compact bone without structure it appears in the roentgen film as the most dense bone in the body, focal sclerotic changes must therefore theoretically either be caused by local thickening of bone or be the result of spongiotic processes in the surrounding bone substance It is possible for extensive regions of otosclerotic bone to be identified in roentgen films when the bone substance is thickened Patchy or linear sclerotic areas may also represent normal compact bone with intervening otosclerotic foci, as suggested by VALVASSORI

The otospongiotic part of the otosclerotic process is said to be a sign of active otosclerosis, although it is not known with certainty if the histologic appearances correspond with different stages in the development of the disease It is suggested that the presence of an uncommonly wide opening corresponding to the oval window, as reported by VALVASSORI, by JENSEN et coll and by the present author, may in fact represent the otospongiotic stage of the otosclerotic process

Conclusion

The otosclerotic process gives rise to changes which may be demonstrated by tomographic examination of the middle and inner ear The most valuable sign seems to be a failure to distinguish any opening corresponding to the oval window, or the presence of a small opening sometimes surrounded by a thickened bone substance It is suggested that a wide oval window corresponds to the otospongiotic stage of otosclerosis Furthermore, focal sclerotic changes in the vicinity of the oval window strongly point to an otosclerotic process A small vestibule, a thick labyrinth capsule, or a large amount of bone substance surrounding the lateral semicircular canal do not seem to be strongly correlated to otosclerotic changes and may be found as often in otosclerotic as in non-otosclerotic patients

As there are no ways other than surgery to permit of an anatomical and topographic evalution of the extent of the otosclerotic process, the investigation of the otosclerotic patient should include a roentgenologic examination with tomography It is possible that further work along these lines, put in close correlation with the clinical examination will help to achieve a more detailed understanding of the otosclerotic process and its clinical behaviour

SUMMARY

A material of 59 patients with signs of otosclerosis have been examined *tomographically* with the Mimer The changes in the middle and inner ear are described and the normal variations are discussed

ZUSAMMENFASSUNG

Tomographie mittels des Mimers wurde an 59 Patienten mit Otosklerose vorgenommen Die Veranderungen am Mittel und Innen Ohr werden beschrieben und die normalen Variationen werden diskutiert

RESUME

Cinquante neuf malades presentant des signes d otosclerose ont ete examines tomographiquement avec le Mimer L auteur decrit les modifications de l oreille moyenne et de l oreille interne et etudie les variations normales.

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EMBOLISM AND SPASM FOLLOWING SUBARACHNOID HEMORRHAGE

by

P A KATSIOTIS and J N TAPTAS

Bilateral carotid and vertebral angiography are routine examination procedures in subarachnoid hemorrhage and often indicate the cause of the bleeding frequently a ruptured arterial aneurysm. A space occupying lesion is sometimes revealed and explains the neurologic signs.

Another frequent association is arterial spasm. This may be single or multiple and usually occurs in the supraclinoid part of the internal carotid artery or one of its major branches. It is generally encountered in young adults as arteriosclerotic changes in the elderly will not allow the vessel to contract (TAVERAS & WOOD). It has been reported although much less frequently, in certain other conditions such as head injuries, infectious meningitis and intraventricular bleeding (GREITZ).

The frequency with which arterial spasm is associated with subarachnoid aneurysm bleeding makes it a valuable sign in cases in which the aneurysm is not filled during angiography, this may happen since an arterial aneurysm after rupture may become thrombosed. It has thus been reported that a previously

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demonstrated aneurysm may have disappeared at a repeat examination (LODIN) The irregular appearance of the arterial lumen close to the site of an aneurysm that has bled (PERTUISET et coll) may also perhaps be explained by defects due to blood clots

The mechanism of arterial spasm is not yet clear Mechanical irritation of the vessel wall is a common explanation Sudden pressure changes due to forceful contrast medium injection during angiography have also been suggested as the cause (LINDBOM) and the local release of serotonin has been mentioned by ALLCOCK The impact of an embolus against the vascular wall causing spasm by mechanical irritation has been suggested by ECKER & RIEMENSCHNEIDER

The pathologic significance of arterial spasm is not obvious It is generally assumed that spasm involves a diminution of blood flow in a given region thereby creating conditions favouring ischaemia Neurologic disorders sometimes observed in cases of aneurysmal subarachnoid hemorrhage without a space occupying lesion are said to be due to ischaemic incidents provoked by arterial spasm This opinion is however not accepted by many since it has not yet been demonstrated whether or not arterial spasm represents a permanent constriction of the vessel or may be provoked temporarily during angiography under certain conditions

The authors believe that small emboli the origin of which is a thrombotic blood clot at the site of the aneurysm that has bled may possibly explain the neurologic accidents and spasm that sometimes occur after subarachnoid hemorrhage without a space occupying lesion as suggested by the following case

Male aged 35 not hypertensive suddenly lost consciousness for some minutes during physical strain On admission he complained of severe left frontal headache and stiffness of the neck Lumbar puncture revealed subarachnoid hemorrhage He soon recovered but on the fifteenth day suddenly developed right hemiplegia with aphasia Left internal carotid angiography was performed two days later A small ovale intravascular carotid filling defect was present in the three radiographic projections immediately above the superior horizontal limb of the carotid artery which appeared spastic There was delayed filling of the inferior branch of the angular artery Both the anterior cerebral arteries as well as the posterior communicating and posterior cerebral arteries were filled No aneurysm was evident (Fig 1)

Right internal carotid angiography was carried out a week later The right anterior cerebral artery was not filled but the posterior cerebral artery was well outlined (anomaly of circle of Willis) No aneurysm or other lesion was observed Vertebral angiography was not performed since the condition of the patient was improving and the neurologic signs were regressing

Three weeks after the hemiparetic accident, the patient was subjected to a further left internal carotid angiography The original intravascular carotid filling defect as well as the spasm had not disappeared There was normal filling of the inferior branch of the angular



Fig 1 Intravascular carotid filling defect projecting just above the origin of the posterior communicating artery Spasm of the supraclinoidal part of the internal carotid artery



Fig 2 Left carotid angiography performed 20 days after the examination in fig 1 The intravascular carotid filling defect as well as the spasm have disappeared

artery but the superior branch appeared slender (Fig 2) compared to its size at the previous angiographic examination The patient was discharged in relatively good health a month after admission At control two months later his condition was satisfactory A third left carotid angiography revealed no change since the previous examination

Discussion

The subarachnoid bleeding episode as well as the associated spasm of the left carotid artery in this case constituted indirect signs of the presence of a ruptured arterial aneurysm, not filled because it had been thrombosed The filling defect seen in the carotid artery immediately above the arterial spasm apparently corresponded to a blood clot projecting into the vascular lumen at the site of the presumed aneurysm

The fact that the patient had a right hemiplegia before angiography was performed rules out the possibility of embolism due to procedure Thrombo-embolus formation due to faulty puncture may be rejected since the needle lay well within the arterial lumen and there was no evidence of mural injection Intercurrent embolism may be reasonably eliminated since defect was observed in a large vessel, i e the left internal carotid artery There was also a delay in contrast filling of the involved vessel, i e the inferior branch of the angular artery, whereas in cases of intercurrent embolism the injection time has been

reported to be normal and that the emptying of the affected vessel is delayed. It would appear more probable that the embolism in the inferior branch of the angular artery originated from the carotid filling defect caused by the blood clot.

Thrombosis of the middle cerebral artery in subarachnoid hemorrhage has been reported (WALSH), although no similar intravascular carotid filling defect and embolism of a second order arterial branch appear to have been reported. Comparison of angiographies performed during or shortly after the bleeding episode and late follow up studies might possibly reveal changes in the arterial pattern corresponding to embolism and subsequent recanalisation of the involved vessel.

SUMMARY

Embolism of the inferior branch of the angular artery in a young adult with subarachnoid bleeding is reported. An intravascular filling defect of the left internal carotid artery was observed at the first angiographic examination but was not present at two subsequent controls. The significance of the findings is discussed.

ZUSAMMENFASSUNG

Embolie im unteren Ast der Arteria angularis wurde bei einem jungen Erwachsenen mit subarachnoidaler Blutung beobachtet. Ein Füllungsdefekt der linken Arteria carotis interna wurde bei der ersten angiographischen Untersuchung observiert; bei zwei späteren angiographischen Untersuchungen war der Füllungsdefekt nicht mehr zu sehen. Die Bedeutung dieser Erscheinungen wird besprochen.

RÉSUMÉ

Les auteurs rapportent un cas d'embolie de la branche inférieure de l'artère angulaire chez un jeune adulte atteint d'hémorragie sous-arachnoïdienne. *Une première* angiographie avait montré un défaut de remplissage intravasculaire de l'artère carotide interne qui n'existait plus sur deux examens de contrôle ultérieurs. Les auteurs examinent l'intérêt de ces images.

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DENSITOMETRIC AND VISUAL EVALUATION OF THE CIRCULATION TIME IN CAROTID ANGIOGRAPHY

A methodologic study

by

TORGNY GREITZ and BERTIL SVK

In the estimation of the cerebral circulation time at angiography the activity of water soluble contrast media in producing cardiovascular reactions is a definite drawback Though the results of circulation time studies have not been shown to be systematically influenced there is no doubt that reactions of this kind have occasionally influenced the measurement It seems reasonable to assume that the relative inactivity of modern contrast media may improve the measurement accuracy in studies of the cerebral circulation time We therefore considered it of interest to study the reproducibility of results obtained in angiographic estimations of the circulation time using a comparatively inactive contrast medium such as Urografin (sodium and methylglucamine diatrizoate) However the accuracy of circulation time measurements by means of a simple naked eye estimation of the maximum density in arteries and veins (GREITZ 1956) may be questioned The results from such estimations have therefore been compared with those obtained from densitometric readings

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Fig 1 Densitometric readings of density variations were made within one area in the carotid siphon (arrow) and within two reference spots By subtracting the mean value of the latter determinations from that with n the siphon the influence of contrast med um accumulation within the brain and of expo ure variations may be eliminated The instant of maximum density in the carotid siphon can then be calculated

measurement The area selected for measurement within the carotid siphon was surrounded by a circle about 3 mm in diameter on each film demonstrating arterial filling Two spots without arterial filling in the vicinity of the carotid siphon were selected and encircled in a similar way to eliminate density varia tions due to exposure or accumulation of contra t medium in the cerebral tissue (Fig 1)

The exposure data were selected in such a manner that the values obtained fell within the linear part of the blackening curve of the roentgen film The mean value of density obtained in these background points was subtracted from the mean value obtained from the carotid siphon Density curves to indicate maxi mum absorbtion in the carotid siphon could thus be obtained On each film demonstrating venous filling a parietal vein was selected and density variations were measured in the same way as for the carotid siphon (Fig 2)

All the estimations were made twice The maxima were also determined twice through simple visual inspection by two independent observers (G and S) who had to consider variations in density within the same circle Any discrepancy between the two observations due to selection of different points of measurement could thus be eliminated The accuracy of the eye in choosing the film of maximum concentration could consequently be compared with that of the densitometer Densitometric values of circulation times were obtained and were put in relation to those obtained by ordinary inspection of films (Table 2)

Results and Discussion

Modern contrast media such as Urografin are much less liable to produce cardiovascular reactions than the older media As a bradycardial reaction when

Table 1

Estimation of the cerebral circulation time in 20 cases at two separate injections and by visual inspection of two independent observers

	Injection time	Longest heart cycle before injection in s/100 (A)	Longest heart cycle after injection in s/100 (B)	Bradycardial reaction in s/100 (B—A)	Circulation time in seconds as estimated through simple visual inspection by two independent observers		
					Observer G	Observer S	Mean
Mean in first series (Injection I)	1.41	74.1	79.3	5.2	4.19	4.33	4.26
Mean in second series (Injection II)	1.36	78.4	81.5	2.9	4.01	4.09	4.06
Difference between means	+0.05	−4.3	−2.2	+2.3	+0.15	+0.24	+0.20
Range of difference between first and second series	−0.20—+0.78	−16—+6	−10—+4	−4—+16	−1.25—+0.75 (+1.75)	−0.75—+1.0 (+2.25)	−1.0—+0.8 (+2.0)

Material and Methods Double estimations of the circulation time were made in 20 consecutive patients referred for angiography of the carotid artery. For visual estimation of the cerebral circulation time two separate injections were made and two sets of 20 lateral films were obtained. Rapid film changing was employed, with two films per second for the first six seconds, one film per second for three seconds and one film every other second for six seconds. Automatic injection through a percutaneously sited needle, automatic recording of injection time, roentgen exposures and ECG were employed in all cases. Five millilitres Urografin 60 % were injected in each series. The circulation time was determined in both series by visual inspection independently by two observers and was defined as *the time interval between maximum filling of the carotid siphon* and the maximum filling of the parietal veins (GREITZ 1956). The bradycardial reaction on each injection was determined by the method of GREITZ & TORNELL 1967 (see Table 1). The results were analysed by conventional statistical methods.

Densitometry was also performed in order to determine the instant of maximum concentration of contrast medium in the carotid siphon and parietal veins. Only one series of films from each of the twenty patients was used for this study. Films demonstrating arterial and venous filling were selected for

Table 2

Results of double estimations in 20 cases

		Difference between first and second determinations			Number of observations without difference	Difference between first densitometric reading and first visual estimation		Number of observations without difference
		Range	Mean	S D		Range	Mean	
Instant of maximum density in carotid siphon as determined by	Densitometer	+0.25–+0.50	0.04	0.09	18			
	Observer G	−0.25–+0.25	0.06	0.09	15	−0.5–+0.5	0.16	12
	Observer S	−0.25–+0.5	0.06	0.09	15	−0.25–+0.5	0.14	11
Instant of maximum density in parietal veins as determined by	Densitometer	−0.25–+0.25	0.08	0.11	15			
	Observer G	−0.25–+0.5	0.14	0.15	11	−0.5–+0.25	0.10	14
	Observer S	−0.25–+1.0	0.18	0.27	12	0–+1.0	0.18	17
Circulation time as determined by	Densitometer	−0.5–+0.5	0.10	0.15	15			
	Observer G	−0.25–+0.75	0.18	0.19	9	−1.0–+0.5	0.24	9
	Observer S	−0.25–+1.0	0.19	0.25	8	−1.0–+0.5	0.21	11

during the angiographic examination There was no definite correlation between the pulse rate and the circulation time

The mean bradycardial reaction was slightly greater following the first injection than after the second one (means 5.2 and 2.9 respectively) There was however no significant correlation between circulation time and bradycardial reaction The changes in pulse rate upon injection were always small The mean injection time was approximately the same for the first and the second series The difference in injection time for each patient between the first and the second series was calculated this difference could not be correlated to differences in bradycardial reaction or circulation time It might therefore be concluded that with modern contrast media the routine evaluation of cerebral circulation times can be made at cerebral angiography without recording the

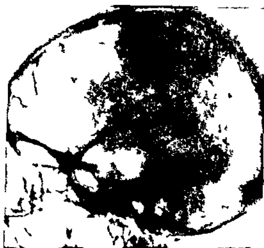


Fig 2 The instant of maximum filling within a parietal vein (arrow) was densitometrically determined in a manner analogous to that described in fig 1

marked, may prolong the circulation time in a variable degree, Urografin might be expected to give values for circulation times that are more easily reproducible than those obtained with the more active acetrizoates (Urokon, Triurol) In a previous investigation with Triurol, GREITZ (1956) found the error of method, including both the error of the observer and variations within the patient to be ± 0 43 seconds In the present material it was found to be ± 0 47 seconds (Table 1) If one of the patients for whom an inexplicable difference much greater than for all the other patients was noted between the two estimations, is excluded from the analysis, however, the error of method is reduced from ± 0 47 seconds to ± 0 35 seconds At the same time, the residual errors, i e those mainly due to variations within the patients, are reduced from 0 43 to 0 30 seconds

The error of the observer was smaller in this series (i e ± 0 18 seconds) than in the Triurol series in which it was ± 0 24 seconds This improved accuracy was mainly due to better reproducibility in the evaluation of maximum concentration in the parietal veins in that the error of the observer in this series was 0 16 as compared to 0 26 seconds in the former For evalution of the maximum concentration in the siphon, the corresponding figures were 0 14 and 0 15 seconds (Table 2)

The circulation times estimated from the first series of films were usually longer than those obtained from the second series (means 4 26 and 4 06, respectively) This difference was significant at the 1 % level This means that the reproducibility of an angiographic estimation of the cerebral circulation time might be increased if comparison between different cases is made from films obtained following injections of the same order The pulse rate was in most cases higher in connection with the second series which means that it increased

und mittels Densitometrie wurde diesen Wert auf 0 15 Sekunden herabgedruckt Die Fehler grenze kann also nicht wesentlich bei Verwendung von Densitometrie reduziert werden.

RÉSUMÉ

Les auteurs ont compare l evaluation visuelle et l evaluation densitometrique du temps de circulation cerebrale determine par angiographie cerebrale L observation visuelle donne une erreur standard de 0 47 seconde L erreur d un observateur unique est de 0 18 reduite a 0 15 par la mesure densitometrique C est pourquoi les auteurs concluent que la densitometrie ne reduit pas significativement l erreur standard de methode

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cardiovascular reactions, providing there is no extravascular injection or other technical source of error.

The densitometric measurement of the point of maximum concentration in the carotid siphon indicated a standard deviation of 0.09 seconds. The standard deviation for each of the two observers with simple visual evaluation was the same, i.e. 0.09 seconds. However, if we assume that the densitometric readings are correct, the mean square error as an estimate of the error of measurement places the error of observer G at 0.26 seconds and that of observer S at 0.20 seconds. *In evaluating the maximum concentration in the parietal veins, the* deviation within the densitometric determination was 0.11 seconds, for observer G it was 0.15 seconds and for observer S it was 0.22 seconds. In evaluating the circulation time from the densitometric readings, the error within the densitometer was 0.15 seconds. The errors for observer G and S were 0.19 and 0.25 seconds, respectively when estimating the density variations through visual inspection of the same small circles in which the densitometric readings were made.

The error of measurement in estimations of the cerebral circulation time is consequently not markedly diminished in the densitometric evaluation. Perhaps even more surprising is the circumstance that despite the fact that the density determinations were made at certain well defined points of the vessels there was no increase to be seen in the accuracy of the estimations of the circulation times. With the densitometric method the S. D. was 0.15. With the conventional method in which the points of measurement are more vaguely defined it was 0.18. This means that in estimations of the overall circulation time little is to be gained from fixing the conventional points of measurement, e.g. in the carotid siphon and the parietal veins, more precisely.

Acknowledgement

This investigation was supported by the foundation Gustav och Thyra Svenssons Minne and by *Riksföreningen mot Cancer*.

SUMMARY

A comparison has been made between visual and densitometric evaluations of the cerebral circulation time at cerebral angiography. Visual observation resulted in a standard *error of* 0.17 seconds. The error of a single observer was 0.18 seconds. In the densitometric determination the error of observer was 0.15 seconds. It therefore was concluded that densitometry does not significantly reduce the error of method.

ZUSAMMENFASSUNG

Die Werte der visuellen und densitometrischen Bestimmung der zerebralen Zirkulationsdauer *bei Angiographie wurden mit einander verglichen.* Die visuelle Beurteilung ergab eine Fehlergrenze von 0.47 Sekunden. Bei einem Beobachter war die Fehlergrenze 0.18 Sekunden

One particular problem has been much discussed i e whether the sometimes observed side effects are caused by the concentration of the solutions or could be due to the total amount of contrast medium given In other words can a certain dose of a contrast medium (or a certain amount of iodine) cause the same pharmacologic effects whether given as a concentrated or dilute solution

It is not the aim of the present study to investigate all aspects of this problem only the circulatory effects produced by intraarterial and intravenous injections of contrast substances will be considered Sodium iothalamate (Conray), the circulatory effects of which are known from a previous study (LINDGREN, SALTZMAN & TORNELL 1968) was chosen for the investigation The vasodilator responses on intraarterial injection are particularly suitable for quantitative evaluation and most of the attention in the present investigation has been given to this effect

It should be pointed out that the observation that higher concentrations may have a disproportionally greater effect than lower ones was made by the authors in one of their first papers (LINDGREN & TORNELL 1958) the phenomenon was however not subjected to any detailed study at that time

Methods The material consisted of 23 cats weighing 2 0 to 3 7 kg anesthetized with sodium pentobarbital (30 mg/kg intraperitoneally) The preparation of the animals was similar to what previously has been described in detail (LINDGREN SALTZMAN & TORNELL 1968) The recording technique has also been the same The blood pressure was recorded in a cannulated carotid artery and the blood flow in the left femoral artery The animals were heparinized (25 mg/kg) Intravenous injections were made via a thin plastic catheter into a cutaneous vein in the foreleg Intraarterial injections were performed through a side tube of the outflow cannula of the blood flow recording apparatus

The sodium salt of iothalamic acid (Conray) was used in the following concentrations

Iothalamate Na	Iodine content (mg/ml)
40 %	240
50 %	300
60 %	360
70 %	420
80 %	480

The vasodilator responses to intraarterial injections of various concentra

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VASCULAR REACTION TO WATER-SOLUBLE CONTRAST MEDIA

Significance of concentration and total amount of iodine

by

P LINDGREN, G F SALTZMAN and G TORNELL

The modern contrast media used for angiographic investigations must have a certain iodine content in order to produce the roentgenographic density necessary for good demonstration of the vessels This goal, good contrast filling, may be accomplished with concentrated solutions of substances having a high amount of iodine in the molecule Modern water soluble media for *intraarterial and intravenous injections all hold three iodine* substitutions in the molecule, placed in 2 , 4- and 6 positions in a 6 carbon ring, the iodine constituting about 60 % of the molecular weight

From the pharmacologic point of view, the concentration of a contrast medium solution, and hence e g the osmolarity, has always been considered a logical classification basis Since certain side effects may be due to the high concentration of the contrast medium, the solutions should be kept reasonably dilute This is however to a great extent prevented by the roentgenologic need to keep a high iodine content per volume for obtaining as good a contrast as possible

A preliminary report was communicated at the 25th Scand Congress of Radiology at Odense 5 to 8 June 1963 Submitted for publication 15 December 1966

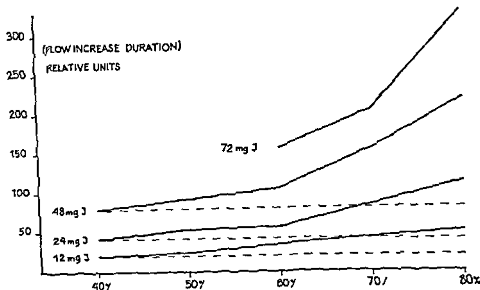


Fig 2 Vascular reaction from a certain amount of iothalamate Na (expressed as iodine) given intraarterially in solutions of various concentrations Mean values of 8 experiments (*The horizontal curves represent vascular reactions calculated on the assumption that the same amount of iodine administered in respectively 40 50 60 70 or 80 solution would have caused the same vascular reactions*)

amount of iodine injected is of greater importance for the magnitude of the vascular response

Another way of arranging the data is illustrated in Fig 2 The concentration of the solution is plotted along the abscissa and the response curves are calculated for certain amounts of iodine If only the factor of the total amount of iodine (and hence the total amount of the substance when only one contrast medium is used) is counted the curves should have been horizontal at various levels The steeper the slope of the curve the more the factor representing the concentration of the solution comes into play It seems as though the step from 70 to 80 % in particular produces the most marked increase in slope when higher amounts are desirable

The data in the dose response material differed considerably from one cat to another because of their individual *sensitivity* A separate series of three experiments was performed in order to simplify the experimental conditions and enable a statistical analysis to be made Solutions consisting of 0 1 ml iothalamate Na 80 % and 0 2 ml 40 % were alternately injected intraarterially at intervals of about 5 minutes That meant that the same amount of substance (and iodine) was given both as a small volume of a highly concentrated solution

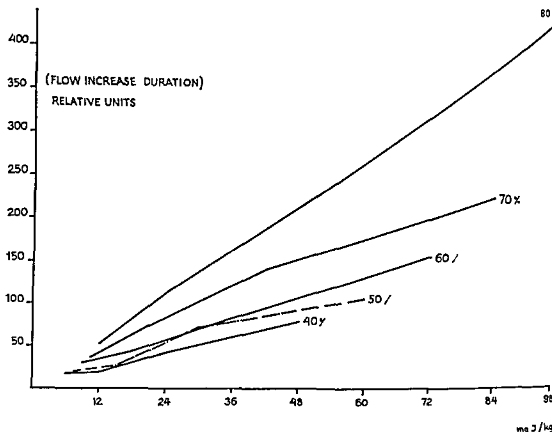


Fig 1 Dose response curves (vascular reaction) from various solutions of iothalamate Na the dose being expressed as the amount of iodine intraarterially injected Mean values of 8 experiments

tions of sodium iothalamate were studied in 8 cats As in a previous investigation (LINDGREN, SALTZMAN & TORNELL 1968) the product

$$\frac{\text{increase in blood flow}}{2} \times \text{duration of response}$$

was used as an estimation of the vascular reaction The authors have previously demonstrated that this method is well suited for a quantitative assay of the 'vascular toxicity' of a contrast medium

If, instead of giving the injection volume in millilitres, the various iodine contents of the doses injected are used as units on the abscissa, dose response relationship curves can be plotted, as in Fig 1 As seen from the curve, the same amount of iodine produces a much more marked reaction when given as an 80 % solution than in a more dilute solution For the lower concentrations of 40 %, 50 %, 60 %, the curves run together, indicating that the difference in concentration plays a smaller role, and that the second factor, the total

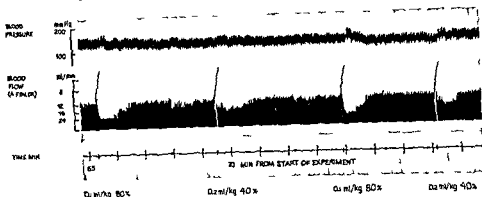


Fig 3 Reco ding of blood pressure and femoral blood flow in an anesthetized cat blood flow changes following alternating intraa terial inject ons of iothalamate Na 80 and 40 %

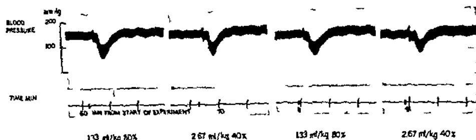


Fig 4 Blood p essure ch nges n an anesthet zed cat registered on intr venous injections of iothalamate Na 80 and 40

high concentrations and often very rapidly There is no doubt that the con centration is an important factor in the circulatory effects that appear as complications on angiographic examinations There are special restrictions put upon the use of concentrated solutions and too large injection volumes for angiography of organs considered to be especially sensitive to the pharma cologic effects of contrast media Cerebral angiography and nephroangiography in particular are two such investigations The present results support such a policy This is of course of the greatest importance when more toxic contrast media are used e g the now obsolete acetrizoate preparations as has been shown by KILLEN & FOSTER (1963) As a matter of principle there seems to be no justification for using higher concentrations of contrast media than necessary in any investigation It may be worth considering for instance whether not the administration of a contrast medium for e g urography and cholegraphy should be made with an intravenous infusion of an isotonic

Table 1

Mean vascular reaction (flow increase times duration relative units) on intraarterial injection of iothalamate

Cat No	Number of injections of each dose	Iothalamate Na 80 % 0 1 ml/kg	Iothalamate Na 40% 0 2 ml/kg
1	6	50 6	26 3
2	9	19 9	10 5
3	6	63 7	53 4

and a larger volume of a more dilute solution The results, vascular reactions, calculated as mentioned above, were subjected to statistical analysis, and it was found that the response caused by the small volume 80 % solution was greater than that caused by double the volume of the 40 % solution The difference was highly significant ($p < 0\ 001$, where p means the probability that the difference is due to chance) Table 1 gives the mean values from the experiments, and Fig 3 illustrates some results in a typical experiment

The great practical importance of the problem appeared to warrant an extension of the investigation to include experiments with intravenous injections of iothalamate substances From the data published in a previous paper (LINDGREN, SALTZMAN & TORNELL 1968) it is obvious that not until quite large doses are given intravenously will the injections cause a blood pressure fall marked enough to be calculated with any accuracy Doses of 0 67 ml/kg produced about the same small blood pressure fall, no matter if the 40 % 60 %, or 80 % solution was used In order to avoid measurement difficulties in the experimental series with alternate injections of the two concentrations, relatively high doses were chosen i e 1 33 ml/kg for the 80 % solution and 2 67 ml/kg for the 40 % solution

A typical experiment, in terms of differences between the 80 % and the 40 % responses, is represented in Fig 4, the cat was a sensitive one, however, and the magnitude of the blood pressure fall was therefore unusually great The main data are given in Table 2 A statistical analysis disclosed that a 1 33 ml/kg 80 % solution caused a greater fall in blood pressure than a 2 67 ml/kg 40 % solution The difference is highly significant ($p < 0\ 001$)

Discussion

Even if modern contrast media must be considered to be of extremely low toxicity and to be safe drugs they deserve special pharmacologic attention Unlike most other solutions for parenteral administration they are injected in

media should therefore always be made with respect to the concentration and iodine content as well as to the volume injected

Another question regarding the cause of side effects from contrast media that has attracted some interest in recent years is the significance of the positive ions of sodium or methylglucamine and the importance of the hyper tonicity of the solutions In the experiments now reported this problem has not been dealt with

Acknowledgements

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SUMMARY

The vascular reactions to intraarterial and intravenous injections of sodium iothalamate (Conray) were studied experimentally in cats The more concentrated solutions gave significantly more intense reactions than dilute solutions even though the same amount of the substance was injected This indicates that the former should be used with care

ZUSAMMENFASSUNG

Die Reaktion des Gefässsystemes auf intra arterielle und intravenose Injektionen von Iothalamat (Conray) wurde experimentell an Katzen studiert Konzentrierte Losungen ergaben bedeutend starkere Reaktionen als schwache Losungen selbst wenn der Gesamtbetrag des Praparates der gleiche war Es ergab sich dass starkere Konzentrationen mit Vorsicht zu gebrauchen sind

RÉSUMÉ

Les auteurs ont étudié experimentalement sur des chats les réactions vasculaires aux injections intra artérielles et intraveineuses d iothalamate de sodium (Conray) Les solutions les plus concentrées ont donné des réactions notablement plus intenses que les solutions diluées même quand la quantité totale injectée du produit est la meme Ceci indique que ce produit doit être utilisé avec précaution

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Table 2

Blood pressure response (decrease times duration relative units) on intravenous injection of iothalamate Na

Cat No	Iothalamate Na 80% 1 33 ml/kg	Iothalamate Na 40° 2 67 ml/kg
1	112 0	44 2
	114 0	93 4
	111 8	91 3
	117 5	76 5
	103 9	86 8
2	9 6	8 6
	20 2	7 5
	31 0	14 7
	61 4	33 ,
3	5 4	3 1
	3 8	3 3
4	15 1	28 8
	51 0	30 1
5	18 2	1 8
	4 8	2 3

solution instead of the usual intravenous injection of a highly hypertonic solution

It may be suggested, on the basis of the present results, that only the most careful use should be made of the high concentrations of iothalamate substances, in particular the 80 % preparation which should be used in this high iodine content per millilitre only when considered necessary It is true that several favourable reports (STRAUBE & DOTTER 1963, MARSHALL & LING 1963) have been published on the contrast medium sodium iothalamate for both urography and angiography, experimental studies support this view and put it in the same safe group as sodium diatrizoate (FUJII et coll 1963, FISCHER & CORNELL 1965, LINDGREN, SALTZMAN & TORNELL 1968) Serious complications as well as fatalities have however also been reported (BERNSTEIN, RELLER & GRAGE 1962, HINCK & DOTTER 1962, STEINBERG & EVANS 1962, LAMPE 1964) All complications can probably never be avoided when contrast media are used in the manner they necessarily are to day Most of the complications in the use of iothalamate substances seem to have occurred in examinations with intra arterial injections of the 80 % preparation It should be pointed out, however, that the iodine content of this agent is much higher than that of most other media used for such investigations The evaluation of side effects of contrast

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FOCAL SPOT VARIATIONS WITH EXPOSURE DATA — IMPORTANT FACTORS IN DAILY ROUTINE

by

OVE MATTSSON

A decrease in the size of the roentgen tube focus will proportionately improve the radiographic recording quality Small foci have been increasingly used in recent years so that a more frequent employment of the magnification technique has become possible Submillimetre foci (e g 0 6 mm diam) are today generally accepted for conventional radiography in all new installations Tomography for geometric reasons usually produces a moderate degree of magnification In systems based on the Grossmann principle, for instance the casette moves below the subject so that a certain clearance is required If the mechanical system of a tomograph is perfectly stable the quality of image projection in the sharp layer will depend exclusively on the focal spot Surprisingly enough no great attention has been paid to this significant fact in considering tomographs The main interest has been concentrated on methods of producing effective tomographic blurring in order to eliminate irrelevant matter and the production of maximum definition of essential detail has been somewhat ignored The moderate degree of magnification produced in all tomographic systems renders the question of focal size of considerable importance

A study of problems connected with film definition especially in tomography revealed a phenomenon that seriously influences the radiographic quality This

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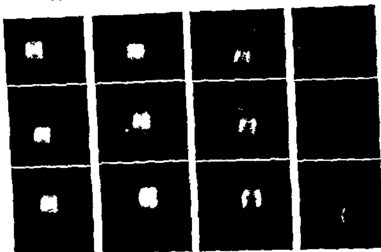


Fig 2 Pinhole camera studies of the focus used in fig 1 The milliamperage was varied stepwise from 10 up to 200 Continuous increase in focal size

series of exposures are presented in Fig 2 The current was varied in each of the four series (from left to right) as follows in the first row with 10, 20 and 30 mA in the second row with 40 60 and 80 mA in the third row with 100 120 and 140 mA and in the fourth row with 160 180 and 200 mA as seen from top to bottom respectively A continuous change of the focal spot occurred its size increasing with marked inhomogeneity The main intensity seemed to be concentrated to the lateral margins with a resultant exaggerated low intensity center A densitometric study of the high current focal spot image is presented in Fig 3 The density recorded corresponded to the intensity measured along a diameter through the centre, which is horizontal compared with Fig 2

Both the general increase in size and the fragmentation of the focal spot seriously influenced the image quality and thus an explanation of the observed reduction in image quality was obtained

A graphic representation of the variations noted in focal diameter with milliamperage is presented in Fig 4 The curve indicates that the increase in focal size takes place mainly above the value 50 mA and is insignificant below it above 100 mA the unfavourable qualities rapidly increase

A comparative study was also made of the larger focus (1 2 mm diam) of the same tube and in this case the highest and lowest current values available were employed The small and large foci are shown together (Fig 5), recorded by a pinhole camera at low and high tube currents respectively Both focal spots, particularly the smaller one changed considerably



Fig 1 Two roentgenograms obtained with the same kV and mAs There is much less definition of detail in the right one as compared to the left

seems previously to have been practically ignored and arises, with certain individual variations, from unit to unit A striking change in image quality was often observed from one exposure to another, although the same tube and identical kilovoltage and milliampere second values were used, and the same object was examined in unaltered position An apparatus for skull and skeletal radiography, with tomography attachment, was used in a particular instance, and the observation was first made in examinations of the wrist joints

The two roentgenograms in Fig 1 were both exposed at 52 kV and 100 mAs on non screen film with a primary magnification of about 30 % The well defined roentgenogram on the left was exposed at a low milliampere value (10 mA), and the less sharp film on the right with a high milliampere value (160 mA) An unmistakeable relation between the degree of sharpness and the milliamperage is evident The exposure times were obviously different but the shorter exposures constantly resulted in reduced definition, a paradox, perhaps as the opposite is usually true

The focus had a nominal size of 0 6 mm A pinhole camera study of the focal spot was made to explain the differences observed in the radiographic rendering

The tube current was varied in steps from 10 mA up to the maximum with the focal spot available while the kilovoltage was kept constant The resultant



Fig 5 Comparison between the small and the large focus in the same tube at respectively the lowest and highest tube currents possible

The exposure data have been especially chosen to eliminate pseudo-sharpness which tends to appear in cases of incorrect exposure (SPIEGLER OLLENSHAW & MACEY 1957) A suitable average value for the density has been fixed at 1 0 as recommended by ROBERTSON & WATSON

All the pinhole camera expoures were made with the central ray of tubes and the recordings thus represent the focus function at the center of the roentgenograms

The observed increase in focal diameter caused a deterioration in image quality by an increase in the penumbral zone as in the use of a focus of larger numerical size to this are added the effects caused by the irregular intensity FRANTZELL (1951) in discussing the radiographic recording of small subfocal sized objects demonstrated that the pattern of intensity variations always present in the focal spot will lead to a similar negative pattern in the recordings of small objects such as very small balls or thin wires The recording of a thin wire in the present case might be influenced by the variation in the focus from low to high current

A series of ro ntgenograms of a thin metal wire produced by low as well as high tube currents are shown in Fig 6 If the wire is placed in parallel with the slit shaped center of the focal spot not only an increase in width will result but a kind of double projection as of two separate fo al spots will be apparent (cf Fig 6d) If the tube is rotated 90° and the wire no longer is parallel with the mean bands of intensity in the focus an entirely different result is obtained (cf

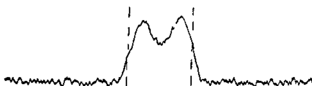


Fig 3 Densitometric study of the focal spot image at high milliamperage

The focal studies presented were performed with a pinhole plate constructed according to KUNTKE (1957) (manufactured by Degussa of Hanau, Germany) The diameter of the pinhole was 30 micron As KUNTKE pointed out, the geometric unsharpness ought not to be more than 10 % of the object size The present hole size is therefore quite sufficient, the value mentioned agreeing with that recommended by ROBERTSON & WATSON (1958) The design of the pinhole plate recommended by KUNTKE has now been accepted as a proposed German standard (CLASSEN 1959) When using pinholes of the size mentioned, very long exposures will be necessary, and the exposures must usually be interrupted by cooling periods for the tube A larger hole (70 micron in diameter) of similar design was used for orientation

As JACOBS (1940) and others have pointed out, a primary magnification of at least × 2 is advisable In our study it has been varied above that value and even exceeded × 3

Non screen film was employed for the pinhole camera studies The contrast at moderate values of density will roughly correspond to that obtained in ordinary roentgen films, and the recording of the focal spot in this way will approximately represent its function in practical radiography The irregularities in the focal spot, as now presented, are thus not exaggerated, in fact, they are slightly reduced, since radiography with non screen film gives a somewhat lower gamma value than that obtained with a screen film combination

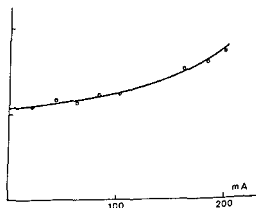


Fig 4 Increase in focal diameter with milliamperage



Fig 7 Variations in the appearance of the focus of three different roentgen tubes The upper row represents high tube currents

facturer on the same type of tubes and with the same technique, present variations in focal size and appearance similar to those now reported

Two tubes from another manufacturer were also examined the results are given in Fig 8 A slight difference in the distribution of intensity within the focal spot at a high current as compared with a low (25 and 180 mA respectively) may be observed There is a more marked concentration of the intensity to the borderline regions as compared with the tubes earlier discussed A slight increase in length with tube current variations may be detected but no other change in dimension An irregular form differing from the square shape that was seen previously is however apparent

A suitable way of evaluating the focal size seems to be by judging the diameter of the circle into which the focus can be introduced a method proposed by BEETLESTONE & THURMER (1958) The diameter of this circle will naturally be influenced by the greatest diagonal of the spot If the focal spot rotates as might be the case in tomography this assessment will be representative of the radiographic result

Although the observed variations in focal size are important they may not have exceeded border values according to accepted standards These are extremely generous possibly with regard to the effects of the type described A critical examination was made by BEETLESTONE & THURMER of the existing American standard and the proposed German *standard* regarding focal spot measurements These authors stress that the American standard in particular tries to cover grossly oversize focal spots by excessive tolerances and give an example A nominal 1 mm focal spot might have a size of 1 6 mm by 1 6 mm and thus a surface exceeding 3 mm The existing excessive tolerances have led to a general acceptance of *oversizes* by the manufacturers Most tubes thus have focal spots considerably exceeding the declared size This fact has been pointed out by KEMP & NICHOLS (1958) who examined a large number *of*

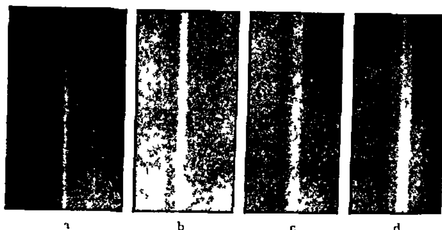


Fig 6 The effects of tube focus irregularities on the appearance of thin wires a) and b) represent low tube current c) and d) high tube current The focal spot was rotated 90 in (b) and (d) as compared to (a) and (c)

Fig 6c) The wire recording is kept much more homogeneous but an increase in width is observed, a result that might be expected

In the studies presented, the same orientation has been maintained during the exposures, the rule in conventional radiography It may sometimes happen in tomography, however, that a circular tube motion includes a rotation of the focal spot in relation to the film A general reduction of definition will then result in relation to the diameter of the active focal spot If the center has a reduced intensity, the rotation will not change it, and effects similar to those discussed may be produced

It must be born in mind that not only the rendering of such small objects like wires will be influenced by irregularities in the focal spot Each contour will have a certain distribution of radiation in the penumbral zone this being influenced by the *intensity irregularities in the focal spot A double contour may thus be* produced if the focus has two separate intensity maxima

The effects described refer to a type of tube commonly used Five different tubes of indentical type were examined with the pinhole camera technique The *results were individually somewhat different two of them were exactly* alike, with the effects now presented, and three of them had the same properties, although less marked A selection of focal studies of these three tubes, at low and high tube currents is presented in Fig 7 the change in intensity distribution towards two separate maxima is evident The increase in focal length is striking but otherwise the change in dimension is modest In these studies, the low milliamperage was 10 and the high milliamperage 160 The exposure conditions were similar to those used in the earlier series Focal studies made by the manu



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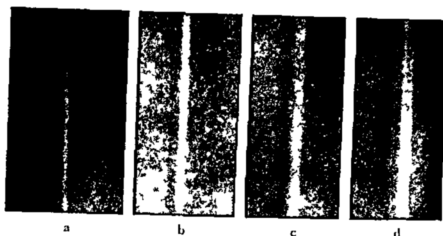


Fig. 6. The effects of tube focus irregularities on the appearance of thin wires. a) and b) represent low tube current, c) and d) high tube current. The focal spot was rotated 90° in (b) and (d) as compared to (a) and (c).

Fig. 6c). The wire recording is kept much more homogeneous but an increase in width is observed, a result that might be expected.

In the studies presented, the same orientation has been maintained during the exposures, the rule in conventional radiography. It may sometimes happen in tomography, however, that a circular tube motion includes a rotation of the focal spot in relation to the film. A general reduction of definition will then result in relation to the diameter of the active focal spot. If the center has a reduced intensity, the rotation will not change it, and effects similar to those discussed may be produced.

It must be born in mind that not only the rendering of such small objects like wires will be influenced by irregularities in the focal spot. Each contour will have a certain distribution of radiation in the penumbral zone, this being influenced by the intensity irregularities in the focal spot. A double contour may thus be produced if the focus has two separate intensity maxima.

The effects described refer to a type of tube commonly used. Five different tubes of indentical type were examined with the pinhole camera technique. The results were individually somewhat different: two of them were exactly alike, with the effects now presented, and three of them had the same properties although less marked. A selection of focal studies of these three tubes, at low and high tube currents is presented in Fig. 7; the change in intensity distribution towards two separate maxima is evident. The increase in focal length is striking but otherwise the change in dimension is modest. In these studies, the low milliamperage was 10 and the high milliamperage 160. The exposure conditions were similar to those used in the earlier series. Focal studies made by the manu-

liberality of roentgendiagnostic demands it would be better to eliminate over sizes than to reduce the nominal sizes still further

It is possible that a series of tests or information regarding each individual tube delivered would make selection easier for the radiologist

SUMMARY

An important cause of decrease in radiographic image quality is analyzed Size variations in the focal spot and significance of tube loading factors are discussed

ZUSAMMENFASSUNG

Eine wichtige Ursache der wechselnden Aufnahmequalitat von radiographischen Bildern wird erlautert Besonders werden Variationen in der Brennfleckgrosse und der Einfluss der Brennfleckbelastung besprochen.

RÉSUMÉ

L auteur a fait des recherches sur les causes de variation de la qualité radiographique des films Il insiste sur l importance des variations dans les dimensions du foyer et étudie l influence des facteurs de charge du tube

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Fig 8 Appearance of the focus of two different tubes at respectively high and low tube currents (the high current to the right in each film)

tubes and studied their focal spots They found that among tubes with rotating anodes the average oversize amounted to not less than 146 %

Both the variation in size of the focal spot with tube current, and the increase in inhomogeneity of the focal spot at higher currents, especially in certain tubes, can well be explained by physical conditions connected with the construction of the cathode Great difficulties are met with in the adjustment of the filament in the cathode cup for producing an acceptable focus at varying exposure conditions A higher current means a higher temperature of the filament and a relatively more intense emission from its ends, where conduction of heat through the suspension system will result in temperature reduction Ienner (1956), in addition, explained size variations of the focal spot by space charges Beese (1937) and Thorp (1959) investigated the genesis of the line structures always present in the radiographic focus, which structures are related to the electric field around the filament and the focussing of the electron beam Thorp demonstrated the appearance of two pairs of lines, termed A and B lines, respectively and demonstrated that they change position in a typical way with adjustment of the filament in the cathode cup According to Ienner, as well as to the last mentioned authors the focussing of the electron beam, and thus the appearance of the focal spot are dependent on both milliamperage and kilovoltage The observations presented in this paper correspond very well with what Ienner demonstrated regarding tube current

Some tubes may have very good qualities which indicates that these phenomena, detrimental to the radiographic image, can be considerably reduced

The importance of small focal spots is constantly growing and techniques are being developed, the success of which is intimately linked with focus quality Much greater attention must be paid to the selection of tubes for high quality radiographic purposes The practical importance of focal variations and irregularities of the character described seems to have been insufficiently recognized The excessive tolerances of nominal and declared sizes give ample evidence of the

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In a comparative clinical study of full size radiography and 16 mm cinefluorography of the gastroduodenal tract (STAPLE & MARGULIS 1961) the skin exposure was estimated to between 12 8 R and 59 4 R (average 39 R) in cinefluorography The speed for cinefluorography was 15 frames/sec The exposure during cinefluorography was estimated to be increased by a factor of 5 as compared with full size radiography

Measurements of integral doses in diagnostic radiology may be useful for epidemiologic studies with special regard to the possible influence on the hematopoietic system from repeated small doses of ionizing radiation (NEBOSCHEW & SCHOTT 1959 GOLDMAN et coll 1960 WACHSMAN 1962 MORGAN & CIGERIC 1964 CARLSSON 1965 OLSSON 1966) The integral doses are easy to measure and the examination is not disturbed by the procedure A graphic record is produced which makes it possible to control in detail the examination techniques of radiologists in training and the patient s integral dose (CARLSSON 1965 OLSSON 1966)

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FROM THE ROENTGENDIAGNOSTIC DEPARTMENT (DIRECTOR PROF OLLE OLSSON),
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INTEGRAL DOSE IN 35-MM CINEFLUOROGRAPHY OF THE GASTROINTESTINAL TRACT

by

J KAUDE

A comparison between full size radiography and 35 mm cinefluorography, with respect to the diagnostic accuracy in the examination of the gastro intestinal tract, with particular reference to ulceration, was made in a pre vious paper (KAUDE 1967) It was found in these investigations that also *small lesions could be demonstrated with 35 mm single films* When motility and morphologic features can be studied with the same technique, cinefluoro graphy may often provide simplified, additional diagnostic information, and the examination time may be reduced

A roentgen examination of the gastroduodenal tract adds an important fraction of the radiation dose to the population This radiation burden has therefore to be investigated before 35 mm cinefluorography is employed as a routine measure for complete gastric examinations

Previous reports JANKER (1953), with cinefluorography from the output screen of an image intensifier, using 16 mm films, measured the skin exposure to be 0 06 R per frame The radiation was pulsed, and the speed of filming was 12 to

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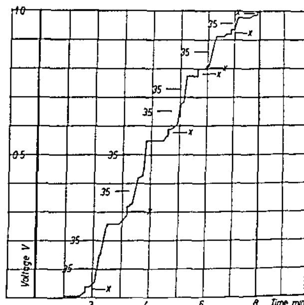


Fig 1 Graphical record of a gastric examination with 35 mm cinefluorography and full size radiography Patient of ordinary habitus normal findings Cinefluorography at 70 kV 10 to 18 mA full size films (×) at 125 kV 5 to 20 mAs fluoroscopy at 80 to 90 kV and 1 mA The integral doses calculated from the record were 9 2 kg rad from cinefluorography 3 2 kg rad from full size films and 2 0 kg rad from the fluoroscopic examination

20 frames/sec with an average of 12 frames/sec Cinefluorography was regarded as a supplementary examination to fluoroscopy and full size radiography of the stomach

The radiation energy delivered to the patient during cinefluorography depends on numerous factors kilovoltage and tube current, filtration of the beam, the distances tube focus patient input screen of the image intensifier, grids, field size, the conversion factor and screen size of the image intensifier, camera optics and shutter, speed and pulsing at filming the size, emulsion and processing of films, the patient s habitus, and finally, on the roentgen findings and the experience and examination technique of the fluoroscopist The exposure measurements reported from cinefluorography in clinical examinations or phantom studies have been carried out with different diagnostic equipment, under varying conditions and with different instrumentation for the measurements The technical data given on the performance of the studies are often incomplete Our knowledge of the integral dose to the patient in cinefluorography of the stomach has so far been limited to the studies of VAN BOHEEMEN (1963)

Present investigation The integral doses were measured in 90 patients, in conjunction with a comparison of the diagnostic accuracy of 35 mm cinefluorography and full size radiography of the gastroduodenal tract (KAUDE) All the patients were examined at the same session with both methods of filming and by the same radiologist The radiation at cinefluorography was not

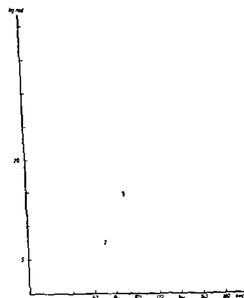


Fig 2 Variations in time and integral dose at 35-mm cinefluorography in 65 examinations of the gastroduodenal tract × — mean integral dose and time per examination ○ — mean integral dose per minute cinefluorography

pulsed filming was performed at a speed of 12 frames/sec Diagnostic equipment recording data film material processing and other technical details have been described in a previous paper on the diagnostic results of this comparison

The measurement of integral doses was carried out according to the methods and with the instrumentation used in the studies reported by CARLSSON (1964 1965) The same methods were also employed for the determination of integral doses in 70 mm fluorography of the gastroduodenal tract (CARLSSON & KALDE) A record of the measurements is given in Fig 1

Results

The mean integral dose in complete cinefluorography of the gastroduodenal tract was found to be 14 9 kg rad (range 4 8 to 38 2 kg rad) The duration of cinefluorography averaged 1 5 min per examination (minimum 39 sec maximum 3 min) and the integral dose rate 10 kg rad/min (minimum 2 1 maximum 24 2 kg rad/min

The integral doses in full size radiography ranged from 1 4 to 9 0 kg rad The mean integral dose was calculated to be 3 7 kg rad Between 7 and 11 films (size 24 × 30 cm, and spot films) were usually obtained at each complete examination

The integral dose in a complete 35 mm cinefluorographic examination of the gastroduodenal tract was increased by a factor of about 4 compared with conventional radiography

Discussion

The integral doses in cinefluorography varied considerably with the time of filming and exposure rate, *the time factor depending mainly on the diagnostic* findings, and the exposure rate on the habitus of the patient Variation caused by eventual difference in examination techniques could be disregarded since all of the examinations were made by the same fluoroscopist (the present author) The variation in the integral doses, and the time required for cinefluorography, are given in Fig 2

A comparison of the diagnoses obtained with conventional roentgenography and 35 mm cinefluorography suggests that it may be possible to reduce the number of full size films or to replace them completely by cinefluorography (KAUDE) This in certain circumstances simplifies the filming, particularly when remotely controlled diagnostic equipment is employed Morphologic features and motility are recorded simultaneously, though *there is a fourfold* increase in the integral dose A decrease in radiation energy, between 40 and 50 %, *may be expected when pulsed cinefluorography is used* (GRIM 1962, VAN BOHEEMEN 1963)

The increase of the integral dose at cinefluorography is also somewhat compensated by a reduction in screening time, this was 2 minutes shorter with cinefluorography than with conventional and 70 mm filming (4 75 min/6 9) in the comparative pilot studies of the stomach and duodenum The integral dose rate in fluoroscopy with the equipment used (Philips 9 image intensifier, Plumbikon TV) ranged from 0 5 to 2 2, mean 1 1 kg rad/min A reduction in the integral dose by approximately 2 kg rad per examination may thus be expected if a complete gastroduodenal examination is carried out with cinefluorography This reduction probably depends on the good detail obtained during filming and observed on a TV monitor

The integral dose in conventional gastric examination, carried out with under and overcouch tubes and a Forssell stand, were measured in our department during the years 1958 to 1961 by CARLSSON (1964 1965) The mean integral doses were found to be between 22 and 44 kg rad, divided into 13 to 26 kg rad from fluoroscopy and 5 to 23 kg rad from full size films *The integral* doses from 35 mm cinefluorography in the present pilot study are consequently comparable with *those from full size films or fluoroscopy performed* with the standard equipment used in previous years

Acknowledgements

The author wishes to thank Ass Prof Carl Carlsson for his advice and interest in this work. The author is also indebted to Mr Robert Krantz for technical assistance

SUMMARY

If 35 mm non pulsed cinefluorography at a speed of 12 frames/sec is used for a complete gastroduodenal examination an increase of the integral dose by a factor of 4 as compared to full size radiography has to be accepted The mean integral dose in the present investigation was approximately 15 kg rad per examination the time for dealing with the stomach averaging 1 5 min with a mean integral dose rate of 10 kg rad/min

ZUSAMMENFASSUNG

Wenn bei Rontgenuntersuchung des Magens das Grossformat Aufnahmeverfahren durch 35 mm Bildverstarker Kinematographie mit einer Bildfrequenz von 12 *Bildern Sekunde ohne* Pulsbetrieb ersetzt wird muss mit einer vierfachen Erhohung der Integraldosis gerechnet werden Die Integraldosis von einer vollstandigen Magenuntersuchung mittels Rontgenkinematographie betrug in dieser Untersuchungsreihe im Durchschnitt 15 kg rad Die Untersuchungszeit belief etwa auf 1,5 Minuten Die durchschnittliche Integraldosisleistung war *10 kg rad/min*

RÉSUMÉ

Si on utilise le radiocinéma en 35 mm non pulsé à 12 *images par seconde pour un* examen gastro-duodénal complet il faut accepter une dose intégrale quadruple de celle donnée par la radiographie *ordinaire La dose* intégrale moyenne dans la présente étude a *été d environ* 15 kg rad par examen le temps d examen de l estomac étant en moyenne d une minute et demie avec un débit de dose intégrale *moyen de 10 kg* rad/min

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FROM THE DEPARTMENTS OF INTERNAL MEDICINE AND RADIOLOGY KORVIN OTTO HOSPITAL BUDAPEST, HUNGARY

SERIAL NEPHROANGIOGRAPHY IN HYPERTENSION

by

ELEONORA HOTOVY ANDRÁS LOSONCI and JÁNOS LAKOS

Serial nephroangiography in hypertensive patients serves not only to demonstrate anatomic kidney abnormalities of the Goldblatt type but also makes it possible to judge the role of the lesion in causing hypertension

Materials and Methods One hundred and one hypertensive patients were examined by percutaneous transfemoral aortography A dose of 0 35 ml/kg bodyweight of contrast medium (Uromiro 75 %) was injected into the aorta at the level of the renal arteries with a Gidlund injector at 6 kg/cm² pressure The injector started the Odelca film changer which during the first four seconds produced ten films under automatic control Further films of the standardized series were made at 10 20 30 90 120 150 and 180 seconds The exact chronologic order of the films was recorded with a Mingograph (Fig 1)

Hypertensive patients with normal kidneys

The duration of the different phases in serial nephroangiography has already been described in experiments carried out in animals (ref 3 30) Although it has been realized that such data are desirable for human subjects (ref 6) they appear to be lacking

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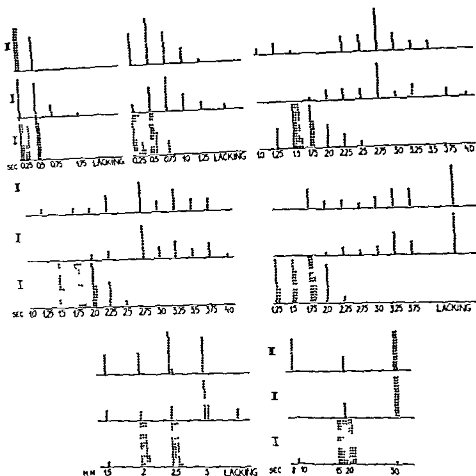


Fig 2 Diagrams showing the different parameters of the serial nephroangiograms *Top left and middle* time of appearance of main renal arteries and the arterial arborization *Top right* time of wash-out of the main renal arteries *Middle left* time of wash-out of the arborization *Middle right* beginning of the differentiation of the nephrographic effect *Lower left* disappearance of the nephrographic effect *Lower right* appearance of the postnephrographic urogram

Every point in the diagrams represents one kidney and the three groups represent group I 53 hypertensive patients with normal kidneys (106 kidneys) group II 25 patients with renal hypertension (37 kidneys) group III 23 hypertensive patients with normal kidneys and abnormal phenomena in the serial nephroangiograms (48 kidneys)

The postnephrographic filling of the pelvis occurs at 2 0 to 2 5 min after the injection of the contrast medium (ref 7) (group I of Fig 2 lower left diagram and Fig 3d)

The normal duration of all these phenomena (quantitative parameters)

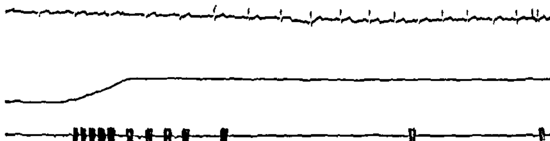


Fig 1 Films in exact chronological order (recorded by a Mingograph) after injection of contrast medium in the same patient as in fig 3

Serial nephro angiograms in 53 hypertensive patients, in ages between 15 and 35 years, were analyzed No abnormalities were discovered in the kidney, the renal function being normal from the usual clinical investigations as well as from the clearance values of the differential function tests performed by individual ureteric catheterization (ref 15)

Results The contrast medium in the arterial phase appears *in the main* branches of the renal arteries and the intrarenal arborization within 0 25 to 0 5 sec after its injection (group I of Fig 2, upper left diagram, and Fig 3 a), and disappears at 1 25 to 2 25 sec (group I of Fig 2, upper right and middle left diagrams)

The first part of the nephrographic phase appears within 0 25 to 1 25 sec after the injection of the contrast medium (Fig 3b) as a filling of the capillaries (cf ref 31) This is followed by filling of the glomeruli at 1 0 to 2 0 sec, and then of the peritubular capillaries (ref 6), the cortex, septum (columna Bertini) and the medulla (group I of Fig 2, middle and right diagrams) The complete nephrogram reaches maximum intensity after the fading of the arborization, with disappearance of the differentiation at 3 0 to 4 0 sec The medium has then entered the medullary circulation and its tubular accumulation and excretion begun (cf ref 9) (Fig 3 c) The nephrogram persists for 20 sec, when it becomes less evident but without disappearing (group I of Fig 2, lower right diagram) The period elapsing from the appearance of the early nephrogram till the disappearance of the complete nephrogram is called the transit time (cf ref 3)

The veins appear within 10 seconds They can usually not be seen, however, indicating that the greater part of the contrast medium, given in a relatively small dose, has been excreted by the renal tubuli (ref 3)

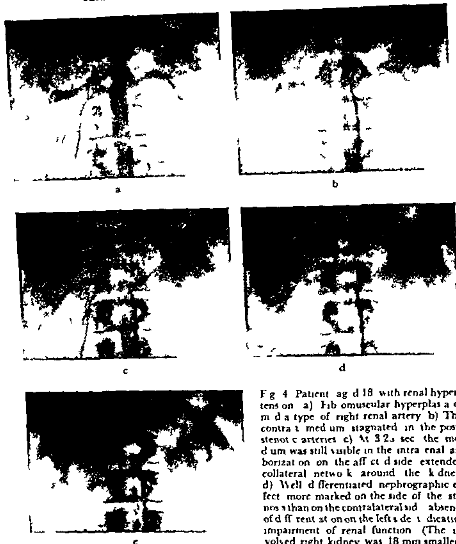


Fig. 4. Patient aged 18 with renal hypertension. a) Fibromuscular hyperplasia of mid a type of right renal artery. b) The contrast medium stagnated in the post-stenotic arteries. c) At 3.25 sec the medium was still visible in the intrarenal arborization on the affected side; extended collateral network around the kidney. d) Well differentiated nephrographic effect more marked on the side of the stenosis than on the contralateral side; absence of differentiation on the left side indicating impairment of renal function. (The involved right kidney was 18 mm smaller.) e) The contrast medium appeared earlier in the right collecting system (at 1.5 min); its density more marked than in the contralateral kidney.

been considered as signs of renal ischemia and have been explained by variations in the hemodynamic conditions with the degree of stenosis. But the fact that these phenomena in some instances, even in cases definitely ischemic, cannot be demonstrated by serial nephroangiography seems to suggest that the hemodynamic changes cannot be the only cause



Fig. 3. Patient aged 17 with normal renal vessels and normal kidney function. a) 0.5 sec. Appearance of renal arteries and arterial arborization. b) 1.0 sec. Early nephrogram and beginning of differentiation. c) 3.0 sec. Complete nephrogram, maximum of differentiation. d) 2 min. Appearance of the urogram

and their normal appearances (qualitative parameters, i.e. the intensity and differentiation of the nephrogram, and the density of the urogram) are identical in both kidneys. The difference in the size of the kidneys in the nephrogram is not more than 1 cm.

Patients with morphologic changes

The ischemic nature of the affection of a kidney will explain why hypertension is probably produced by a lesion of the Goldblatt type.

Some authors have suggested that the duration and appearance of the radiologic phenomena in serial nephroangiography, in unilateral kidney lesions (renal artery stenosis), are different in the ischemic kidney in comparison to the contralateral normal kidney (ref. 5, 6, 16, 25, 27). These phenomena have



Fig 6 Patient aged 53 with malignant hypertension Right renal artery occluded and not filled Stenosis of the left renal artery the contrast medium stagnated in the post stenotic area (at 4 sec) Late appearance of early nephrogram extended collaterals on both sides b) Nephrograph effect on left side marked (at 2.5 min) renal pelvis not yet visible The contrast medium by way of collaterals filled the right atrophic kidney

(Fig 4c) Further valuable radiologic signs of renal ischemia in every significant and permanent obstruction of the circulation due to any cause, are the appearance of collaterals (ref 2 24) and a decrease in the size of the affected kidney (ref 12) (Fig 4c) In the evaluation of the area of the kidneys it must be remembered that the size of the left kidney is physiologically greater than the right and that normal kidneys may contract during serial nephroangiography (ref 13 23)

Authors opinions vary as to the intensity of the nephrogram of the involved kidney The nephrogram is usually described as being of diminished density (ref 6 16 27, 28) although the effect often appears to be more marked than on the normal side (ref 6 29) The present authors feel however, that the explanation of the phenomenon lies in a consideration of the renal function which in the present material was established by the clearance values of the differential renal function tests and renal biopsy

If the kidney function is good and in spite of the decreased blood supply the nephrons are normal and function well the paradoxical hyperconcentration of the nephrogram may be explained The ischemic kidney produces an increase in sodium and water resorption As a consequence of the post stenotically slower circulation and the increased resorption the appearance time of the nephrogram is normal and its disappearance is delayed, that is the transit time becomes longer The intensity of the nephrogram is increased and the differentiation becomes normal (Fig 4d) The veins appear late In such cases the postnephrographic urogram will show the contrast medium to appear early and clearly on the pathologic side (Fig 4e) partly corresponding to what has been found by other authors in the excretory urogram (ref 11 16)

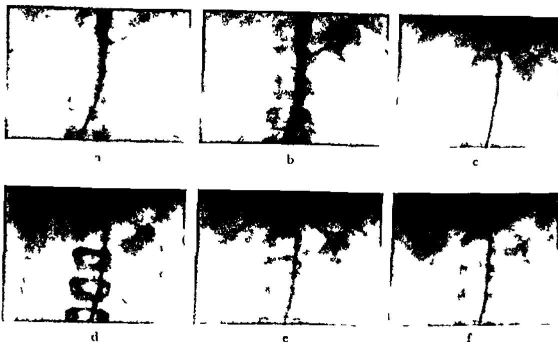


Fig 5 The patient was a 9 year old girl with excessive hypertension a) and b) Fibromuscular hyperplasia of intima type of right renal artery single mural fibrosis of left renal artery delayed appearance (at 1 75 sec) of both kidneys collaterals on both sides c) Right renal artery stenosis with impaired renal function decrease in intensity and differentiation of the nephrographic effect Stenosis of left renal artery but good renal function paradoxical hyperconcentration evident d) After 30 sec bilateral nephrographic effect still visible transit time delayed e) Delayed appearance of right urogram but the contrast medium had already appeared (at 1 5 min) on the left side f) 3 min the density of the urogram decreased on the right side and increased on the left

Renal function depends on the hemodynamics of the kidney, from which it cannot be separated It therefore plays an important role in renal lesions and should always be considered in the evaluation of a series of nephroangiograms

In our analysis of serial nephroangiograms, 25 patients with renal hypertension were included

The importance of renal artery stenosis is determined by the degree to which it hinders the blood flow to functioning renal tissues Depending on the degree of obstruction, the blood flow becomes slower following stenosis, and a pressure drop across the area of narrowing occurs The degree of stenosis thus determines the size of the pressure gradient If it exceeds a certain value, 40 to 50 mm Hg (cf ref 5 16) the stenosis is hemodynamically significant (ref 5) With stenosis of this degree, the kidney is always ischemic (ref 18)

Results The radiologic signs of a *hemodynamically significant stenosis* are that the contrast medium stagnates in the poststenotic arterial system (Fig 4, a and b), and its wash out is delayed in measurable units of time (ref 27)

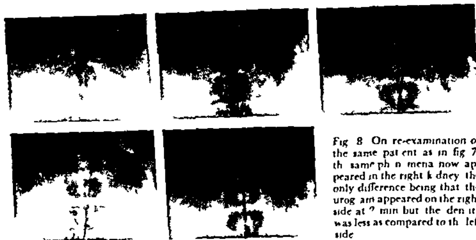


Fig 8 On re-examination of the same patient as in fig 7 the same phenomena now appeared in the right kidney the only difference being that the urogram appeared on the right side at 2 min but the density was less as compared to the left side

vascular lesions of different degrees and types (Figs 5 and 6) In view of the fact that degenerative vascular *abnormalities may be developing in a kidney* with no stenotic artery normal serial angiograms on the contralateral side cannot be expected Comparing with the normal quantitative SNA data it may however be possible to draw conclusions as to the degree of deterioration of the renal function in these kidneys (cf Fig 4d)

Thus serial nephroangiography enables a judgment to be formed upon the degree of the stenosis and on the ischemic nature of an affected kidney It also provides a basis for drawing conclusions on the function of both the affected and the contralateral kidneys This has been carried out by a unified evaluation of the qualitative radiologic phenomena described by others by the standardization of the serial nephroangiograms by the introduction of time as a quantitative factor as well as by judging the function as exercising an influence on the formation and appearance of the radiologic phenomena The role of renovascular abnormalities in causing hypertension may thus be explained

Functional renal ischemia in patients without morphologic changes

This part of the material consisted of 23 young hypertensive patients in ages between 17 and 35 years In spite of the fact that no anatomical lesions were evident in the serial nephroangiograms and the differential renal function tests were normal (ref 15) yet differences similar to those present in patients with morphologic changes were apparent

The data on the different parameters of the serial nephroangiograms are presented in Fig 2 they include those of the normal group I, the pathologic group II and the so called functional group III, as described before

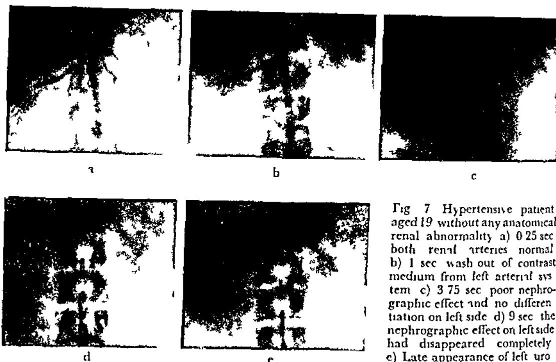


Fig. 7. Hypertensive patient aged 19 without any anatomical renal abnormality. a) 0.25 sec both renal arteries normal. b) 1 sec wash out of contrast medium from left arterial system. c) 3.75 sec poor nephrographic effect and no differentiation on left side. d) 9 sec the nephrographic effect on left side had disappeared completely. e) Late appearance of left urogram (at 2 min).

With deterioration of the renal function, the phenomena in the nephrogram and postnephrographic urogram are delayed or absent, and the time of appearance of the nephrogram is delayed (Fig. 5, a and b), but as its disappearance time is even more delayed, the transit time becomes longer (Fig. 5d). The intensity and differentiation of the nephrogram is decreased and the cortex is thin, or is not differentiated (Fig. 5c). The appearance time of the postnephrographic urogram is late (Fig. 5e) and the density of the contrast medium in the collecting system is not marked, or it may even be decreased (Fig. 5f). The kidney, as a consequence of the impairment of function, and in proportion to the latter, is thus not capable of producing the radiologic phenomena of paradoxical hyperconcentration, either in the nephrographic or the pyelographic phases. The presence of collaterals is consequently of decisive importance in the absence of these signs of renal ischemia (Fig. 5b).

In extreme impairment of the renal function, the nephrogram appears late (Fig. 6a), or is undifferentiated, and in addition persists a long time, that is, the transit time becomes very long (Fig. 6b). Great delay, or no excretion of contrast medium into the pelvis, may occur. All these are the consequences of poor renal function.

On the basis of normal nephroangiographic data it is possible, however, to indicate when renal ischemia is present and to assess the renal function in bilateral

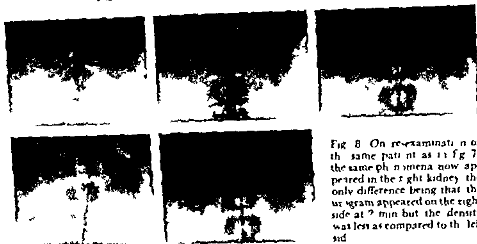


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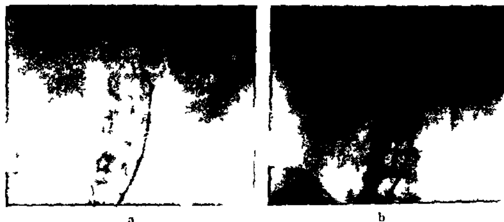


Fig 9 Patient aged 28 without anatomical kidney abnormality a) Well differentiated right nephrographic effect b) Normal right nephrographic effect At 10 sec, the great vein was not visible but the left renal vein was well filled The phenomenon is due to opening of the periglomerular and arteriolo rectovenous shunts causing the contrast medium to pass into the slow medullary circulation and the wash out is delayed

Results The appearance time of the great arteries and of the arterial arborization are identical in all the three groups (Fig 2) but this was not true of the wash out of the former and disappearance of the latter, both of which were delayed in the two groups II and III, (Fig 2, top right and middle left) The cause of the phenomenon in group II is the decrease in the pressure gradient With prerenal vascular abnormality, the pressure gradient decreases because there is a pressure drop after the stenosis, whereas in diffuse vascular and parenchymal renal disease the decrease in the pressure gradient is caused by the increased peripheral vascular resistance The cause of the decreased pressure gradient in group III may be explained partly by spasm of the renal artery (Fig 10 b) and partly by the increase in the peripheral vascular resistance of the kidney occurring during the investigation

The transient and abrupt increase in the peripheral vascular resistance causes different shunts in the kidney to be opened and various types of nephrographic effects to occur

In spite of the normal outlining of the kidney contours, the differentiation may be delayed or absent in group III (Fig 2, middle, right diagram) and the transit time may be altered (Fig 2, lower, left diagram) If the quantitative data as well as the qualitative parameters are considered, two main types of nephrographic phases may be recognized in the material When of the first type, the nephrogram appears at a normal time and disappears completely after 10 sec, i e the transit time becomes shorter The effect is slight and the differentiation is absent The large veins can be seen early, i e within 3 to

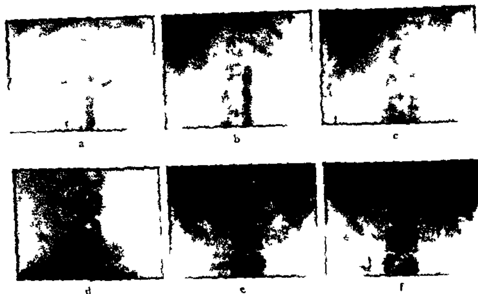


Fig 10 Patient aged 18 without any sign of renal lesion a) Both renal arteries intact b) Spasm of right renal artery c) Well differentiated and marked right nephrographic effect d) Marked density and early appearance (at 1 5 min) of the contrast medium in the collecting system right kidney e) Routine urography No excretion of left kidney f) Normal excretion of both kidneys on repeat urography

4 sec *This type may* be explained by the opening of the larger arteriovenous *anastomoses* (ref 30) as a result of which the contrast medium by passes the functioning parenchyma (ref 8 10) This phenomenon is demonstrated in a case in which it appeared at the first investigation of the left kidney (Fig 7) and at repeat investigation of the right kidney (Fig 8)

When the nephrographic phase is of the second type the contour of the kidney is evident at the normal time the differentiation appears and the nephrographic effect is not slight It persists longer, i e the transit time is delayed and the veins cannot be defined The phenomenon may be explained by the fact that due to the opening of the periglomerular and arteriolo rectovenous shunts (ref 4) blood passes into the *slower medullary* circulation *The wash out of the contrast medium is thus delayed (Fig 9)*

With serial nephroangiography however it is possible not only to observe functional phenomena and circulatory changes but which is more important their consequences can be evaluated The paradoxical hyperconcentration of the nephrogram was thus evident *in some* patients with whom the increase in the peripheral vascular resistance *or* the transient spasm *of the renal* artery was present in the nephroangiograms (Fig 10 a to c) The nephroangiographic

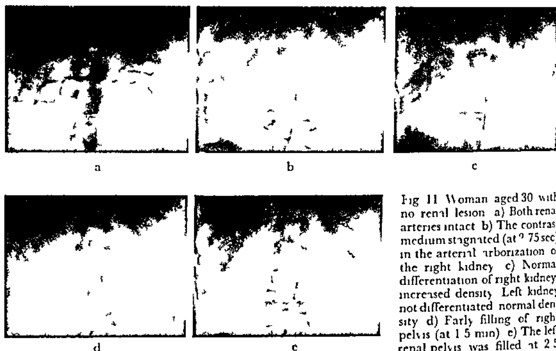


Fig 11 Woman aged 30 with no renal lesion a) Both renal arteries intact b) The contrast medium stagnated (at 2 75 sec) in the arterial arborization of the right kidney c) Normal differentiation of right kidney increased density Left kidney not differentiated normal density d) Early filling of right pelvis (at 1 5 min) e) The left renal pelvis was filled at 2 5 min e) At 2 5 min the left renal pelvis filled The right pelvis was more dense increased peripheral vascular resistance thus produced signs characteristic of functional renal ischemia on the right side Phenomena of the 2nd type of shunts evident on the left side

phenomena in these instances are the same as in hemodynamically significant renal artery stenosis with good kidney function It can therefore be stated that the increase in the peripheral vascular resistance of the kidney or the transient spasm of the renal artery may be accompanied by hemodynamic consequences identical with stenosis and create transient renal ischemia The proof of this lies in the paradoxical hyperconcentration of the contrast medium evident in the nephrogram and the postnephrographic filling of the pelvis (Fig 10d)

As may be seen from Fig 2, the lower, right diagram, as far as the appearance time of the postnephrographic urogram is concerned, groups I and III will not differ This means that the transient hemodynamical disturbances described may be compensated for by the normal function of the tubuli However, depending on the type and duration of such disturbances and the actual state of the potentially intact tubuli, the excretion may be delayed, or even absent, as a sign of maximal disturbance of the tubular function This phenomenon was observed in the left kidney of a patient during routine urography (Fig 10 e), in which spasm of the right renal artery had been evident in the angiogram Both kidneys were otherwise normal on serial nephroangiography, there was also no abnormality in the clearance values in the differential renal

function tests and on repeat urography (Fig 10f) The non function of the left kidney in the first urographic examination cannot therefore be explained by anatomical kidney abnormality

We have also observed instances where during the same examination one type of the functional phenomenon was visible in the right kidney and the other type in the left kidney of the same patient (Fig 11)

The phenomena described in the arterial and nephrographic phases of serial nephroangiography may also appear isolated in different segments of the kidney mainly in the lower poles

Consequently similar phenomena appeared on serial nephroangiography of some of the young hypertensive patients with normal clearance function as in those with pathologic conditions

The authors believe that the functional abnormalities observed are the manifestations of the hyper response of the arterial system that is characteristic of essential hypertension On the other hand in pathologic conditions in which the vessel reactivity is normal or even decreased (ref 4 20) the appearance of the phenomena may be due to the anatomical lesions themselves

The fact that the radiologic phenomena are of different types and even sometimes vary in the two kidneys of the same patient is evidence that the kidney does not necessarily react in the same way to the same stimulus or to the same complex of stimuli It means at the same time that the kind of reaction is decisively determined by the momentary state of the kidney The vascular and tubular effect of the hormones in question (epinephrine angiotensin) are concerned with innervation (ref 19 20) the basis of which is constituted by the receptor apparatus in both the vascular and tubular system of the kidney (ref 1) It explains depending on the actual state of the nervous system the varied effect of the hormones caused by the increased arterial reactivity characteristic of essential hypertension (ref 14 22)

Other authors have described similar functional phenomena observed at serial nephroangiography (e g renal artery spasm (ref 21)) and increased peripheral vascular resistance (ref 3 21) but have failed to point out their consequences It is evident that such changes may lead to functional ischemia of the kidney which may play a role in the pathomechanism of essential hypertension

SUMMARY

One hundred and one hypertensive patients were examined by serial nephroangiography Twenty three of these with apparently otherwise normal kidney had evidence of certain functional renal changes These may lead to functional renal ischemia which in turn may play a role in the pathomechanism of essential hypertension

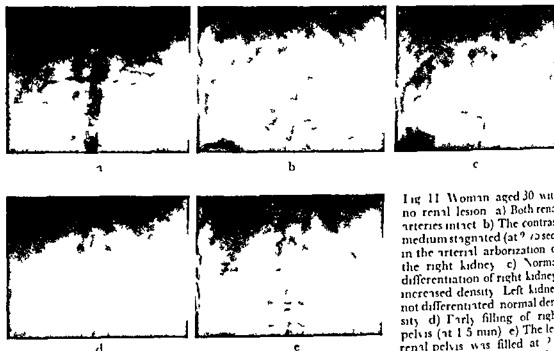


Fig. 11. Woman aged 30 with no renal lesion. a) Both renal arteries intact. b) The contrast medium stagnated (at 2.5 sec) in the arterial arborization of the right kidney. c) Normal differentiation of right kidney, increased density. Left kidney not differentiated, normal density. d) Early filling of right pelvis (at 1.5 min). e) The left renal pelvis was filled at 2.5 min. e) At 2.5 min the left renal pelvis filled. The right pelvis was more dense: increased peripheral vascular resistance thus produced signs characteristic of functional renal ischemia on the right side. Phenomena of the 2nd type of shunts evident on the left side

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As may be seen from Fig. 2, the lower, right diagram, as far as the appearance time of the postnephrographic urogram is concerned, groups I and III will not differ. This means that the transient hemodynamical disturbances described may be compensated for by the normal function of the tubuli. However, depending on the type and duration of such disturbances and the actual state of the potentially intact tubuli, the excretion may be delayed, or even absent, as a sign of maximal disturbance of the tubular function. This phenomenon was observed in the left kidney of a patient during routine urography (Fig. 10 e), in which spasm of the right renal artery had been evident in the angiogram. Both kidneys were otherwise normal on serial nephroangiography, there was also no abnormality in the clearance values in the differential renal

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ZUSAMMENFASSUNG

Die serienweise Nephroangiographie wurde an 101 Patienten mit Hochdruck vorgenommen Von diesen Fällen zeigten 23 im ganzen normale Nieren, trotzdem waren gewisse Erscheinungen vorhanden welche zu einer renalen funktionellen Ischaemie führen können die ihrerseits später wirklichen Hochdruck hervorbringen kann

RÉSUMÉ

Cent et un malades hypertendus ont été examinés par angiographie rénale en série Vingt trois de ces malades ayant des reins par ailleurs apparemment normaux présentaient des signes angiographiques certains de troubles fonctionnels rénaux Ces troubles peuvent amener une ischémie rénale fonctionnelle qui à son tour peut jouer un role dans le mécanisme pathogénique de l hypertension essentielle

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FEMALE PELVIC VEINS DEMONSTRATED BY SELECTIVE RENAL PHLEBOGRAPHY WITH PARTICULAR REFERENCE TO PELVIC VARICOSITIES

by

N Chidekel

The major pelvic veins in women are the common external and internal iliac veins branches of the latter according to RAUBER KOPSCH may be described as visceral or parietal veins

Visceral veins These consist of a number of communicating plexuses and their drainage veins

1 The vesical venous plexus is situated perivesically and receives among other supplies the flow from the dorsal clitoral vein drainage from the plexus taking place via the vesical veins

2 The vaginal venous plexus is most developed around the side walls of the vagina and continues cranially to the uterine venous plexus

3 The uterine venous plexus is situated mainly around the lateral parts of the uterus and partially fills the parametrium According to WEGRYN & HARROW (1960), the vaginal venous plexus and the caudal portions of the uterine venous plexus are drained via the uterine veins These vessels usually consist of three branches on each side and are formed at the level of the uterine

From Roentgen Department III (Director Docent O Bartley) Sahlgrenska Sjukhuset Gothenburg Sweden Submitted for publication 12 May 1966

Book reviews

AN ATLAS OF DETAILED NORMAL PNEUMOENCEPHALOGRAPHIC ANATOMY By Giovanni di Chiro 327 pages 282 illustrations Charles C Thomas Springfield 1961 Price 19 dollars

This is a book of illustrations with explanatory diagrams, of which the normal roentgenographic anatomy of the intracranial subarachnoid cisterns and ventricular system as revealed by fractional gas encephalography It also contains a short description of the larger arteries and of their relations to the arteries of the brain

The structures which are full size unfortunately are not all depicted from the best angle despite the fact that there is plenty of space As far as the reviewer can judge the films are anatomically correct and are sufficiently detailed to be of practical value to those for whom the book is intended neurologists neurosurgeons and neuroradiologists Only a few of the anatomical variations are mentioned however It would doubtless have been of value to have had a short summary of the commonest variations of diagnostic interest such as a fluid or gas filled cavum septi pellucidi and the different forms of posterior and temporal horns The book demonstrates the value of tomography in the interpretation of topographical anatomy and also that the technique of axial transverse encephalography as described by the author is a useful complementary procedure

Although it is several years since this book was published the reviewer has observed that it has been and still is extensively used in many departments. Its lucidity and clarity and the high quality of its illustrations would thus appear to constitute justifications for proclaiming it a work of lasting significance

Gunnar Westberg

ANGIOGRAPHIE IN DER KNOCHENPATHOLOGIE Von L Mucchi I F Goidanich und S Zanoli 172 Seiten mit 104 Abbildungen in 522 Einzeldarstellungen Georg Thieme Verlag Stuttgart 1966 Preis 77 DM

The rich vascular network in highly malignant mesenchymal tumours may be demonstrated by angiography and spectacular angiograms are easily obtained A study of the angiographic findings in neoplastic and other pathologic processes requires histopathologic and micro angiographic examinations no such investigations are included in this work Angiograms of pathologic processes in bone tissue are described but the authors do not discuss the connection between the vascularity and degree of malignancy Tumours of low malignancy which are difficult to judge angiographically and to treat satisfactorily are summarily dismissed In sufficient emphasis is placed upon the fact that is is hard to distinguish between an inflammatory and a neoplastic process by means of angiography One of the cases illustrated (Fig 29) is described as a metastasis and confirmed in the text by photomicrography although labelled in the legend as osteomyelitis A typical juxtacortical osteogenic sarcoma (Fig 86) is called a fibrosarcoma probably because only the soft part of the tumour was examined Certain cases were diagnosed as giant cell sarcoma a term not included in modern classifications Some of the names of the authors are so distorted as to be unrecognizable The quality of several of the roentgenograms might be better

Åke Lindbom

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AHLBERG BARTLEY & CHIDEKEL (1963) performed left sided renal phlebography in 17 female patients in the erect position The entire left ovarian vein in 13 of them was contrast filled in a retrograde direction and therefore the visceral pelvic veins were also filled

TAVERNIER & LANGE (1965) described a patient in whom the tip of the catheter at left sided selective phlebography by chance came to lie at the orifice of the ovarian vein the latter vein as well as the pelvic veins were then contrast filled in a retrograde direction These investigators reproduced the technique in 7 other patients In five out of the eight patients thus examined the pelvic veins were contrast filled and in one of them pelvic varicosities were observed It was not stated in the report whether the examination was performed with the patients supine or erect

Intraosseous contrast injections have been made at different sites for example into the pubis ischium iliac crest sacrum and greater trochanter (DUCUING et coll 1951 KAHR 1953 BEGG 1954 GREITZ 1955 HILSCHER 1955 LESSMAN & WALDROP 1958) Usually only the parietal pelvic veins were contrast filled, but when a drainage obstruction existed in a major vessel the visceral veins could also be demonstrated (HILSCHER)

Contrast injection of the genital tissues has been performed in the corpora cavernosa clitoridis (DUCUING et coll) and in the uterine wall (GULHEM et coll 1951 TOPOLANSKI SIERRA 1958 WEGRYN & HARRON HUGHES & CURTIS 1962 PALI et coll 1963 SCHLESSLER & HEINEN 1963 and BUHL & LEFEVRE 1964) With the former method the same veins were contrast filled as with injection made into the dorsal clitoral vein The most complete contrast filling of the visceral pelvic veins was obtained by injection into the wall of the uterine fundus with this method the uterine venous plexus as well as the ovarian venous plexuses were demonstrated

When pelvic varicosities a condition with abnormally broad and convoluted veins are suspected this is an important indication for roentgen examination of the visceral pelvic veins According to EMGE (1925) the widening of the pelvic veins is seldom limited to a single group of veins but usually includes veins belonging to both the uterus and the ovaries HELANDER & LINDBOM (1960) have roentgenologically defined the condition using as a criterion the width of the widest communicating vein between the uterine and ovarian veins They stated that varicosities exist in non pregnant women when the diameter exceeds 5 mm

RICHET s report (1857) describing a case of tubo ovarian varicocele has been followed by many clinical reports on the subject e g DUDLEY (1888),

cervix. They pass to the lateral pelvic wall and then cranially to the internal iliac vein. The portion of the uterine venous plexus that is situated around the fundus of the uterus is drained in part by the uterine veins and in part by abundant anastomoses to the ovarian venous plexus.

4. Drainage from the ovarian venous plexus takes place via the ovarian vein which on the left side, almost without exception, empties into the renal vein and on the right side usually directly into the inferior vena cava.

5. The rectal venous plexus has abundant communicating anastomoses with the uterovaginal venous plexus, drainage taking place via the superior rectal vein to the portal system as well as via the internal iliac vein.

6. The labial veins, deep clitoral veins, and the inferior rectal veins drain into the internal pudendal vein, which empties into the inferior gluteal veins.

Parietal veins. These consist of (1) the iliolumbal veins, (2) the superior and inferior gluteal veins, (3) the obturator veins (these, however, empty sometimes wholly or partly into the external iliac vein), and (4) the sacral venous plexus, which is formed by the lateral sacral veins and the lateral branches of the medial sacral vein and communicates with the rectal venous plexus.

Roentgenologic demonstration of the pelvic veins may be accomplished after injection of contrast medium into arteries, veins, bone marrow or genital tissues.

To demonstrate arteriovenous fistula of the uterus and adnexa in pregnant and non-pregnant women BORELL & FERNSTRÖM (1958) injected 40 to 50 ml contrast medium into the aorta after compression of both femoral arteries. Exposures were made no later than 4 sec after the end of the injection. The frequencies of contrast filling of the pelvic veins were 25 % and 0.6 % (43 of 172 pregnant women and 2 of 345 non-pregnant women with various gynecologic diseases).

Some investigators (BAUX & POULHES 1950, PETKOVIC 1953, GUILHEM & BAUX 1954) injected contrast medium into the dorsal clitoral vein after surgical incision. The contrast-filled visceral pelvic veins were parts of the vesical venous plexus and the most laterally situated parts of the uterine veins, the obturator and the gluteal veins were also filled. A number of investigators, e.g. FARINAS (1947), DALALI et coll. (1954), HILSCHER (1955), BARTLEY (1958) and HELANDER & LINDBOM (1959, 1960) have studied the extent of expansive processes in the pelvic cavity by injecting contrast medium into the long saphenous vein, the femoral vein or the external iliac vein. Retrograde passage of contrast medium to the internal iliac and the presacral veins and occasionally to the visceral veins was noted when compression of the inferior vena cava was performed. HELANDER & LINDBOM's material consisted of 300 women, the majority of whom

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MILLER & KANAVEL (1905), EMGE (1921), FOTHERGILL (1921), CASTANO (1925), MATTSON (1936), MARTINI (1950), FEGERL & NARIK (1954), and EDLUNDH (1964) EMGE and FOTHERGILL, among others, have classified varicose veins of the female pelvis as primary and secondary in type The pathogenesis has not been elucidated but these authors stated that secondary varicosities may be caused by pathologic processes in the pelvic cavity such as neoplasm, chronic infection, and uterine displacement MARTINI found pelvic varicosities at laparotomy at a frequency of about 1 % in 4 710 women with gynecologic disorders, while HELANDER & LINDBOM noted a frequency of about 3 % at phlebography The last mentioned authors, like FEGERL & NARIK, have observed pelvic varicosities only in women who had borne children

The *symptomatology, pathogenesis and therapy have been described by* EDLUNDH in a clinical report which concerns the greater part of the present material The symptomatology will therefore now be described only briefly It has been maintained in the literature that the most common symptoms are pain and heaviness in the pelvis, particularly after prolonged standing, backache, secondary dysmenorrhea, marked dyspareunia and leukorrhea Furthermore, EMGE pointed out that these patients, when up and about, often have irritable bladder without demonstrable changes in the urine According to FOTHERGILL, the aforementioned symptoms usually disappear with the menopause

A condition with similar symptoms is the so called pelvic congestion syndrome described by e g TAYLOR (1954) According to TOPOLANSKI SIERRA and WEGRYN & HARRON, the pelvic congestion syndrome comprises a preliminary stage of pelvic varicosities

Conservative therapy has had very little effect on the symptoms of pelvic varicosities On the other hand, various surgical measures have been of value (CASTANO MATTSON, EDLUNDH and BUHL & LEFEVRE) Since neither the symptomatology nor the clinical findings seem to be sufficiently characteristic for a definitive diagnosis to be established, a precise roentgenologic method would be of value

The left ovarian vein almost without exception opens into the left renal vein, and therefore selective renal phlebography can be employed to study the pelvic veins provided valves in the gonadal vein are either absent or incompetent In three earlier reports (AHLBERG BARTLEY & CHIDEKEL 1965a b 1966) have shown that 13 % to 15 % of the women in these materials lacked valves in the cranial portion of the left ovarian vein and that 35 % to 41 % had incompetent valves The corresponding figures for the right side were 6 % and 43 % Thus the anatomic conditions for retrograde *flow existed in about half the* number of cases The frequency of incompetent valves and the width of the gonadal

veins were significantly greater among multiparae than among nulliparae. In the first of the reports mentioned it was questioned whether or not there is a relationship between retrograde flow in the left gonadal vein and varicocele scroti in men and pelvic varicosities in women. The relationship with varicocele scroti in men was considered in detail in an earlier paper (AHLBERG, BARTLEY, CHIDEKEL & FRITJOFSSON 1966), while the present report is concerned with the corresponding problem in women.

Material. This consisted of 75 consecutively investigated patients from two gynecologic departments. The mean age of the patients was 36 years (range 24 to 55 years); the oldest patient was menopausal while the others were in the fertile years. Pelvic varicosities were clinically suspected in 61 of the patients; these had one or more of the following symptoms: pain or heaviness in the pelvis particularly after prolonged standing, secondary dysmenorrhea and dyspareunia. The remaining 14 patients were investigated as a control material.

The primary diagnoses prior to roentgen examination for the patients with clinically suspected varicosities were: dolores abdominis in 33, meno- and/or metrorrhagia in 9, dysmenorrhea in 5, dyspareunia in 5, endometriosis in 3, and in the remaining 6 patients myoma uteri, cysta ovarii dextra, salpingitis chronica, dysplasia cervicis, sterilitas secundaria and cystitis, respectively.

The primary diagnoses for the fourteen patients without clinically suspected pelvic varicosities were: dolores abdominis in 3, meno- and/or metrorrhagia in 7, and in the remaining 4 patients myoma uteri, cysta ovarii sinistra, adenomyosis uteri and colpitis, respectively.

Methods. The technique ealier described by AHLBERG, BARTLEY, CHIDEKEL & FRITJOFSSON (1966) will now be briefly outlined only. The patients were premedicated with promethazine chloride and pethidine chloride. Local anesthesia was employed with the percutaneous puncture of (usually) the left femoral vein. A No. 205 catheter (ODMAN 1955) was inserted into the left renal vein under monitor screen control. Two injections each of 40 ml Urografin 76 % (Schering) were made with a Gidlund Elema pressure syringe adjusted to 2 kg/cm². The tip of the catheter was in one patient inserted into the cranial portion of the left ovarian vein and selective phlebography was carried out in this vein. The films were exposed with the patients erect by employing a tilting table. FFD was about 85 cm; manual film changing was employed. The region investigated included the left renal and gonadal veins and the veins in the pelvic cavity. Two series of films (35 cm × 35 cm) were required to cover the investigated region. The cranial portion was exposed 2 sec and 7 sec after the start of the first contrast injection; usually four exposures were obtained of the caudal part

after the second injection. In the course of the investigation, the exposure schedule was changed for the second series: 5, 15, 40, and 75 sec proved to be suitable times after the start of the contrast medium injection. Early in the investigation, some films were obtained as late as at 210 sec.

The results obtained with this technique have been compared with those observed with the same patients in supine position, as well as with findings obtained by means of retrograde pelvic phlebography according to HELANDER & LINDBOM. The first comparative investigation comprised 47 patients and the subsequent one 29. The retrograde pelvic phlebography examination was performed after selective renal phlebography. When the last mentioned examination had been made, the patients were instructed to urinate, and a second catheter No. 205 was inserted into the other femoral vein. The tips of the catheters were placed in the external iliac veins about 10 cm from the puncture sites. The inferior vena cava was compressed with the aid of a compression belt and a rubber ballon, up to a pressure of about 1 kg/cm². A total of 40 ml Urografin 45 % was then injected through the catheters, with a pressure of 2 kg/cm. The investigation was carried out with the patients supine, and five exposures were made at 2 to 14 sec after the start of the contrast medium injection.

No complications were observed in any of the examinations. As with the roentgen examination of men, the risk of thrombosis was reduced by ensuring that the patients were up and about soon after the examination.

The diameter of the left ovarian vein was measured on the films 10 mm caudal to its opening into the renal vein, and the presence of valves in the ovarian vein was noted. When competent valves were observed less than 10 mm from the renal vein, the diameter of the ovarian vein was measured immediately cranial to the valves. When a communicating vein was noted between the left ovarian vein and the lateral portion of the renal vein or one of its branches, the diameter of the ovarian vein was measured 10 mm caudal to the orifice of the anastomosis. When the pelvic veins were contrast filled, the diameter of the widest of the uterine veins was measured. The measurements were made 1 cm above the level of the cranial portion of the acetabulum where the uterine veins run vertically.

The same tilting table and FFD were employed in another investigation (CHIDEKEL & EDLUNDH) in which an enlargement factor of 1.4 was invariably found for the site of the cavum uteri. Since the ovarian vein is at almost the same distance from the film as the cavum uteri, the same enlargement factor could be used. Enlargement has however been disregarded, and the diameters of the ovarian veins given in the present report are the absolute figures, to the nearest millimeter, measured on the films.



Fig 1 a) Group I at 2 sec after start of contrast medium injection into the left renal vein Wide ovarian vein completely filled in a retrograde direction b) Group II at 2 sec Competent valves in ovarian vein (→) suprarenal vein and veins of the lumbar plexus filled from the renal vein (The kidney pelvis and the ureter were filled at an earlier contrast injection) c) Group I at 2 sec Wide ovarian vein contrast filled in a retrograde direction from the renal vein and one of its branches the latter also communicates with a lumbar vein

The time for the maximal contrast filling of the uterovaginal plexus and the uterine veins was interpolated on the basis of the degree of contrast filling of these veins in the series of films The intent has not been to study the circulation rate of the contrast medium but rather to estimate at which time maximum contrast filling occurred in order to establish a suitable exposure schedule for routine purposes

In addition to the clinically suspected pelvic varicosities the following data were recorded age of patient phase of menstrual cycle at the time of roentgen examination number of pregnancies interval between last pregnancy and roentgen examination and the occurrence of changes considered to give rise to secondary pelvic varicosities such as neoplasm in the pelvic cavity chronic infection and uterine displacement Finally the frequency of phlebolites in the pelvic cavity was noted

Table 1

Relation between number of pregnancies and width of ovarian vein

Number of pregnancies	Number of patients	Vein diam Mean (mm)	St
Total Material			
0	6	3.3	1.58
1	13	5.2	3.73
2	22	6.7	9.70
≥3	33*	6.3	6.18
Group I			
0	1	3	—
1	8	6.4	1.43
2	14	8.4	9.97
≥3	21*	7.5	2.59
Group II			
0	5	3.4	1.84
1	5	3.4	1.44
2	8	3.8	1.69
≥3	12	4.1	1.93

* The patient with duplication of the ovarian vein was not included

Results

The total material was divided into two groups on the basis of the results of the selective renal phlebographies performed with the patients erect. Group I comprised 45 patients in whom the entire ovarian vein (Fig. 1a) and some other pelvic veins were contrast filled. Group II consisted of 30 patients in whom the left ovarian vein was only partly contrast filled, on the average for 36 mm of its length (Fig. 1b).

Incompetent valves in the left ovarian vein were demonstrated in 16 of the 45 patients in group I. One pair of valves was demonstrated in each of 13 patients, two pairs in two patients and three pairs in one patient. The valves in the latter patient were situated 0.8 cm, 14 cm and 15 cm caudal to the renal vein, while in all the others the valves were observed less than 10 cm from the renal vein.

Twenty six of the 30 patients in group II had demonstrable valves in the ovarian vein less than 6 cm caudal to the renal vein. A single pair of valves, situated on the average 11 mm caudal to the renal vein, was noted in each of

19 patients in thirteen of whom the valves were competent, while in the other six the contrast medium passed on the average 69 mm caudal to the valves Two pairs of valves were observed in each of the other 7 patients situated on the average 34 mm apart and with the most caudal pair at a distance of 51 mm from the renal vein In two of these patients both pairs of valves were incompetent and contrast medium passed 23 mm and 108 mm caudal to the valves In the other five instances the caudal pair of valves was competent

A communicating vein between the ovarian vein and the lateral portion of the renal vein or one of its branches was present in each of 4 patients in group I (Fig 1c) The retrograde contrast filling of the ovarian vein was implemented by the anastomosing vein in every instance the anastomoses emptied into the ovarian vein 22 to 76 mm caudal to the renal vein

The veins of the lumbar plexus were filled from the renal vein in 36 patients of the total material (see Fig 1b)

The branches from the left ovarian plexus to the ovarian vein in group I combined into a common vessel at varying levels in 8 patients caudal to S1 in 9 at S1 in 9 at L5 in 15 at L4 in 3 at L3 and in one patient the ovarian vein was duplicated up to the renal vein This patient was excluded when estimating the mean value for the diameter of the ovarian vein

The mean value for the diameter of the left ovarian vein in group I was 7 5 mm (range 3 to 14 mm $S^2 = 5\ 30$) and in group II it was 3 8 mm (range 2 to 6 mm $S^2 = 1\ 82$) The left ovarian vein was highly significantly wider in group I than in group II ($t = 8\ 83$) Several patients in group I had however veins of a width similar to those of many in group II On the other hand the diameter of the ovarian vein in patients in group II never exceeded 6 mm, while in group I this occurred in 28 patients i e in 64 % Within group II no significant difference in the diameter of the ovarian vein was found in patients with or without competent valves

The diameter of the left ovarian vein was investigated in relation to the number of pregnancies and to the number of children born In the total material (Table 1) the diameter of the left ovarian vein was significantly greater in patients who had been pregnant than in the nulligravidae (1 pregnancy $t = 2\ 57$ 2 pregnancies $t = 3\ 99$ 3 or more pregnancies, $t = 4\ 39$) Similar calculations were not made for group I with only one nulligravida and no significant differences were evident between the nulligravidae and the other subgroups of group II No significant differences between the subgroups of gravidae were found in the total material or in groups I and II The statistical findings were the same when the number of children born was substituted for the number of pregnancies

The contrast medium in group I passed from the visceral pelvic veins to the

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Table 2

Frequency of various pelvic veins in group I demonstrated by left sided renal phlebography performed with the patient erect

	Number	%
Left ovarian plexus	45	100
Right ovarian plexus	38	84
Right ovarian vein	9	20
Left uterovaginal plexus	45	100
Right uterovaginal plexus	36	80
Left vesical plexus	38	84
Right vesical plexus	33	73
Left obturator and external pudendal veins	20	44
Right obturator and external veins	20	44
Sacral veins	16	36

made between patients with an ovarian vein diameter between 3 and 8 mm and those over 8 mm The former category comprised 18 patients with a mean diameter for the uterine vein of 5 3 mm ($S^2 = 0\ 70$), in the latter category consisting of 9 patients the corresponding value was 6 2 mm ($S^2 = 0\ 64$) The patients with an ovarian vein diameter of over 8 mm had significantly wider uterine veins than the others (t = 2 70)

In the patient in group II in whom selective left sided ovarian phlebography was carried out the diameter of the widest uterine veins on each side was 4 mm this figure is the same as the lower limit of values in group I The other veins in the pelvic cavity of this patient (Fig 4) were also smaller than those in the majority of patients in group I

The pelvic veins were contrast filled in the following order the left ovarian plexus the uterovaginal plexus the right ovarian plexus the vesical plexus and finally the obturator and external pudendal veins The uterovaginal plexus and the uterine veins were maximally contrast filled on the left side on the average at 13 sec after the start of the contrast medium injection (range 5 to 43 sec) while the corresponding veins on the right side were contrast filled a few seconds later On the average the vesical plexus was observed to be maximally contrast filled at 36 sec (range 14 to 85 sec) and the obturator and external pudendal veins at 73 sec (range 28 to 140 sec) after the start of the injection Contrast medium remained in the visceral pelvic veins in every instance at the time of the last exposure (70 to 210 sec after the contrast injection)

Of the 47 patients investigated supine 33 belonged to group I and 14 to



Fig. 2. Group I. a) At 5 sec. Wide left ovarian vein and wide veins of the ovarian and uterine plexuses are contrast filled. b) At 10 sec. Uterine plexuses partly emptied and right ovarian vein filled in an antegrade direction (→).

internal iliac veins via the uterine and vesical veins (Figs. 2 and 3) and the obturator veins. Moreover, the right ovarian and the external pudendal veins were contrast filled in some patients. The frequency of contrast filling of the different veins is given in Table 2. The obturator and external pudendal veins cannot be definitively differentiated in the films and have been presented in the table as a single group. The various pelvic veins, with certain exceptions were demonstrable with high frequency on both sides but more often on the left side than the right. The diameter of the widest uterine veins could be measured bilaterally in 13 patients, on only the left side in 14 because of insufficient contrast filling on the right side, and in the remaining 18 patients the measurements could not be made because of either superimposed projection of veins or insufficient contrast filling. Of the 13 patients in whom bilateral measurements were possible the uterine vein had the same width on the two sides in ten patients. The difference in diameter in the other three was 1 mm, in two of these the veins were wider on the left side. The mean diameter for the left uterine vein was 5.6 mm and for the right uterine vein, 5.9 mm (range 4 to 7 mm bilaterally). No significant difference in diameter between the two sides was noted. Comparison of the diameters of the uterine veins was



Fig 4 Group II at 4 sec Selective phlebography of the left ovarian vein The veins of the ovarian and uterine plexuses were narrower than those in the majority of patients in group I

No other visceral veins including the ovarian veins were outlined No communicating veins between the ovarian and uterine veins as described by HELANDER & LINDBOM were observed consequently their width could not be compared with the findings presented by those authors

As was stated before, a significant difference was found between groups I and II in regard to the width of the left ovarian vein Some of the factors mentioned under the heading Methods have been examined more closely in regard to differences between the two groups clinically suspected pelvic *varicosities* existed in 89 % of group I and in 70 % of group II This difference *is statistically* significant (u = 2 07)

When the material was subdivided in regard to the number of *pregnancies the* following results were obtained in *group I there were* one nulligravida 8 primigravidae and 36 multigravidae, in group II *the corresponding* figures were 5 5 and 20 There were significantly more nulligravidae in group II than in group I (u = 2 26) The two groups *did not* differ significantly in the frequency of primigravidae or multigrav*idae although* multigravidae dominated in group I

There were no statistically *significant differences* between the groups in the following respects mean age *in group I was* 37 years (range 25 to 55 years) and in group II it was 35 years (range 24 to 44 years) At the time of the investigation 42 % of the patients in group I were in their first half of menstrual cycle 45 % were in the second half *11 % had* metrorrhagia and 2 % were menopausal The corresponding *figures for* group II were 47 % 40 % 13 % and 0 % respectively The interval between *the most* recent pregnancy and the roentgen examination in group I was on *the average 8* years (range 1 to 23 years) and in group II it was 9 years (range 2 to 22 years) Changes that could possibly



a b

Fig 3 Group I a) At 2 sec Wide left ovarian vein and the ovarian plexus are contrast filled b) At 10 sec Wide uterine (←) and vesical veins a vein (↑) on the right side probably an external pudendal vein is contrast filled

group II The ovarian vein was only partially contrast filled on the average for 78 mm (range 12 to 185 mm) in 7 of the patients in group I, in whom therefore no pelvic veins could be demonstrated The various pelvic veins were contrast filled at a lower frequency in the other 26 patients when examined supine as compared to erect Eight of the 19 patients with bilateral contrast filling of the uterovaginal plexus in erect position had contrast filling only on the left side when supine In no instance were the vesical plexus, the obturator and external pudendal veins contrast filled with the patient supine In the 14 patients in group II who were examined supine the left ovarian vein was contrast filled for a shorter distance in this position in five (mean difference between supine and erect 73 mm), the results were the same in eight patients while in one the ovarian vein could be traced caudally 29 mm farther with the patient supine

Retrograde pelvic phlebography with compression of the inferior vena cava was carried out in 13 patients of group I and in 16 patients of group II In every instance the internal iliac and presacral veins were contrast filled In six patients in group I, and five in group II the uterine or vesical veins were visible for 1 5 to 5 cm from the internal iliac vein either on the left side or bilaterally

In the present study, selective renal phlebography was performed only on the left side since almost without exception the left ovarian vein empties into the left renal vein When using this method with the patient erect the pelvic veins could be demonstrated in 60 % of the total material This frequency corresponds well with the figures from the autopsy material On the other hand since the present material was selected this rate does not necessarily imply that the pelvic veins in an unselected material would be contrast filled with the same high frequency Theoretically a higher frequency would be obtained if a similar examination were carried out on the right side in those patients in whom retrograde filling was not achieved in the left gonadal vein The right ovarian vein empties into the renal vein in approximately 7 % of women and in others it courses to either the inferior vena cava of both of these veins (AHLBERG et coll to be publ) The anatomic conditions in the cranial portion of the right ovarian vein have been examined (AHLBERG et coll 1966) and have in the main been found to be analogous to those on the left side Competent valves on the left side have been seen in some patients with no valves or incompetent valves on the right side When this occurs and the right ovarian vein empties into the renal vein selective right sided renal phlebography can be employed with advantage Another method of increasing the frequency of contrast filling of the pelvic veins consists in carrying out selective phlebography in an ovarian vein Despite the presence of competent valves this was successful in one patient of the present material It should be possible to obtain a high frequency of contrast filling with selective catheterization of the gonadal veins by means of a catheter with a maneuverable tip

Phlebography for the demonstration of pelvic varicosities is usually carried out in fertile women so the roentgen dose should be kept as low as possible When retrograde contrast filling of the entire ovarian vein can be achieved four exposures of the pelvic region have proved adequate and if the obturator and external pudendal veins need not be examined three exposures will be sufficient

The concept of pelvic varicosities is poorly defined they are characterized by wide and convoluted veins belonging to the ovarian and uterine plexuses Measurements of the veins have earlier been made only by HELANDER & LINDBOM who stated that pelvic varicosities existed when the widest communicating vein between the uterine and the ovarian veins in non pregnant women was of a diameter greater than 5 mm Several investigators employing the transuterine technique have reported that the interval from the start of the contrast medium injection to the disappearance of the medium from the pelvic veins was prolonged when pelvic varicosities were present Such information varies however markedly in the literature PALI et coll stated that in women

give rise to secondary pelvic varicosities, such as neoplasm in the pelvic cavity, chronic infection and uterine displacement, occurred in 73 % of group I and in 67 % of group II The frequency of phlebolites on one or both sides in the pelvic cavity was 40 % in both groups

Discussion

The visceral pelvic veins may be studied roentgenologically by means of retrograde pelvic, transuterine or selective renal phlebography, a successful examination with any one of these three methods requires, however, certain conditions

Contrast filling of the visceral pelvic veins at pelvic phlebography with simultaneous compression of the inferior vena cava may be achieved when valves are lacking in the internal iliac veins and in the uterine or vesical veins, or when valves are present but incompetent to the pressure resulting from the compression These conditions were observed in 11 of 29 patients Visceral veins were contrast filled for only a few centimeters, but whether they were uterine or vesical veins could not be ascertained No anastomosis between the ovarian vein and a uterine vein, as measured by HELANDER & LINDBOM, was contrast filled in any of the patients in the present material

Necessary conditions for the demonstration of visceral pelvic veins with the transuterine technique are that the contrast medium be deposited in the myometrium and that its passage into the pelvic veins be rapid Acceleration of the passage can be achieved by a previous injection of hyaluronidase into the myometrium Transuterine phlebography is a common and reliable method for *obtaining contrast filling of the visceral pelvic veins*

It is essential for a study of the visceral pelvic veins by means of selective left sided renal phlebography that there be no valves in the left ovarian vein, or if present that they be incompetent It was noted in an autopsy material (AHLBERG et coll 1965 a, b) that these anatomic conditions existed in about half the number of the women and that the majority of these, more often multiparae than nulliparae, had incompetent valves A comparison of the *results obtained at selective left sided renal phlebography* in erect and supine positions seems to indicate that the former posture has certain advantages *Better, or at least the same amount of information was obtained* in all patients but one, when they were examined erect, as compared to supine The exception was a patient in group II, in whom the ovarian vein was *contrast filled* for a few additional centimeters when supine The cause of this divergent finding may be that no exposure was made at the moment of maximal contrast filling of the ovarian vein with the patient erect

the veins is often noted The valves probably become incompetent for this reason and anatomic conditions for a flow in a retrograde direction will thus be present Retrograde flow may increase the width of the pelvic veins how ever the same factor which causes the widening of the ovarian vein might also be responsible for the widening of the pelvic veins Occasionally autopsy specimens from nulliparae had wide ovarian veins and incompetent valves therefore factors other than pregnancy may be of etiologic importance

The veins of the ovarian and uterine plexuses are wider with pelvic varicosities than under normal conditions Since the pelvic veins were not filled with contrast medium in group II (except one case investigated by means of selective ovarian phlebography) the possible connection between the width of the ovarian vein and that of the pelvic veins could not be studied by means of a comparison between the groups On the other hand a significant relation between the diameter of the ovarian vein and that of the uterine veins was evident in group I Patients with wide ovarian veins also had wide uterine veins In order to compare the two groups in regard to the width of the uterine veins some patients from groups I and II have been examined with the transuterine technique (CHIDEKEL & EDLUNDH) Additional information on the direction of flow of the contrast medium in the ovarian veins may also be obtained with this method

SUMMARY

Percutaneous selective renal phlebography has been carried out in 75 female patients in the erect position The entire ovarian vein and some of the pelvic veins were contrast filled in 60 % of the patients In analogy comparing the findings in men with and without varicocele and the results of the present investigation it is suggested that pelvic varicosities exist when at renal phlebography an ovarian vein is entirely contrast filled in a retrograde direction

ZUSAMMENFASSUNG

Perkutane selektive renale Phlebographie wurde an 75 Patientinnen in aufrechter Stellung vorgenommen in 60 % von diesen wurden die gesamte Ovarialvene und einige der Beckenvenen mit Kontrastmittel gefullt Ein Vergleich zwischen den Befunden bei Mannern mit und ohne Varicocele und den vorliegenden Resultaten deutet darauf hin dass Beckenvarizen wenn eine Ovarialvene bei Nierenphlebographie in ihrer Gesamtlange in retrograder Richtung ausgefullt ist vorliegen

RÉSUMÉ

L auteur a pratiqué une phlébographie rénale selective percutanée en station debout chez 75 femmes chez 60 % de ces femmes la veine ovarienne a été injectée en entier ainsi que quelques unes des veines pelviennes L auteur suppose que d apres les résultats de ce travail et par analogie avec les résultats chez les hommes avec et sans varicocele le remplissage rétrograde par la phlebographie rénale d une veine ovarienne indique l existence de varices pelviennes

without pelvic varicosities the interval was 3 min while the corresponding figure presented by TOPOLANSKI SIERRA was 20 sec. The latter author moreover observed that the disappearance time in certain instances of pelvic varicosities was normal. Thus, no uniform roentgenologic criteria for the presence of pelvic varicosities could be found in the literature.

It has been maintained (MATTSON 1936) that varicocele scroti in men and pelvic varicosities in women are analogous conditions. At selective renal phlebography in men with and without varicocele scroti (AHLBERG, BARTLEY, CHIDEKEL & FRITJORSSON), the diameter of the spermatic vein varied between 4 and 11 mm in patients with varicocele, while the corresponding values for patients without varicocele were 3 and 7 mm. Varicocele thus existed even though the diameter of the spermatic vein was no greater than that in subjects without varicocele. On the other hand, all of the patients with a diameter of the spermatic vein over 7 mm had varicocele. The findings in women in the present investigation were as follows. In group I, with complete retrograde contrast filling of the ovarian vein, its diameter was between 3 and 14 mm. In group II, comprising patients in whom the ovarian vein was only partially contrast filled, the corresponding values were between 3 and 6 mm. Ovarian veins with diameters between 3 and 6 mm therefore occurred in both groups. When the diameter exceeded 6 mm, retrograde contrast filling of the entire ovarian vein occurred in every instance. The gonadal vein in men with varicocele was significantly wider than in the group without varicocele, and the same was true for the women in group I, as compared to those in group II. Since all of the subjects with varicocele scroti had retrograde contrast passage in the spermatic vein, and this finding was never observed in the control group without varicocele, it would seem reasonable to expect analogous findings in women. This would imply that pelvic varicosities exist when complete retrograde contrast passage is demonstrated in an ovarian vein.

The precise cause of the occurrence of pelvic varicosities in women is not clear. It has been suggested (HELANDER & LINDBOM, TEGERL & NARIK) that the condition is only observed in women who have borne children. AHLBERG et coll. (1965 b, 1966), in an autopsy material, found that pregnancy was a factor of importance in relation to the width of the ovarian vein and the occurrence of incompetent valves. The width was significantly greater and the frequency of incompetent valves significantly higher in multiparae as compared to nulliparae. The validity of the first observation has been confirmed in the present material. A comparison between groups I and II disclosed that the frequency of multigravidae was greater in the former but the difference was not statistically significant. The ovarian veins widen during pregnancy (HODGKINSON 1953) and even long after a pregnancy a certain widening of

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Ureteric imprint due to widened veins has been described with renal vein thrombosis (ABESHOUSE 1945 SCANLON 1963) and with varicosities in the ureteric veins (BERMAN & COPELAND 1953 KESHIN & JOFFE 1956 WOODARD 1962 GILLENWATER BURROS & NACKPHAIRAJJ 1963 KAUFMAN & MAXWELL 1964) WOODARD observed varicosities in the ureteric veins in a case of varicocele scroti

TAYLOR & BOYES (1964) described multiple notches in the left ureter which according to the authors interpretation were caused by a varicose ovarian vein Pyelography of a 48-year old woman with a stone in the left ureter revealed pyelovenous back flow to a vein that emptied into the veins in the medial portion of the upper pole of the left kidney instead of into the left renal vein According to the authors the vein was a dilated ovarian vein with an anomalous course The vein caused multiple notches in the upper third of the ureter No reports of similar findings appear in the literature The present authors have however in several instances observed indentations into the ureter at the site where it was crossed by the ovarian vein

Material and Method The material was selected from a group of 75 women and 35 men who had been investigated with selective left renal phlebography for the demonstration of pelvic varicosities (CHIDEKEL) and varicocele s roti (AHLBERG et coll 1966) The present material (30 females and 13 males) includes only those patients in whom the left ureter as well as the left gonadal vein were contrast filled Of the 30 women investigated 19 had pelvic varicosities Left varicocele scroti had been demonstrated in 9 of the 13 men

Urography with compression of ureters was not performed Selective renal phlebography was carried out following percutaneous puncture of the femoral vein (usually on the left side) and insertion of a catheter The patients were examined either in the erect position or both erect and supine

Results

Ten of the 30 women had a clear imprint on the ureter at the site of the crossing of the gonadal vein This change was not observed in any of the men Of the 10 patients with ureteric imprint eight had pelvic varicosities The width of the imprint varied between 3 and 12 mm and was in eight patients the same as the diameter of the gonadal vein while in one it was 2 mm and in the remaining patient 1 mm wider than the vein The imprint was observed only at the site of the crossing of the vein and appeared as a band like craniocaudal decrease of contrast medium always with parallel lateral margins (Figs 1 and 2) No other pathologic changes were demonstrated in the urinary tract there was no hydronephrosis or hydro-ureter The only difference in regard to the imprints

FROM ROENTGEN DEPARTMENT III (DIRECTOR PROF. O. BARTLEY), SAHLGRENSKA SJUKHUSET, GOTHENBURG, SWEDEN

URETERIC IMPRINT CAUSED BY THE LEFT GONADAL VEIN

by

O. Bartley and N. Chidekel

Ureteric changes with stricture, stenosis or imprint may be caused by a number of different conditions. The following causes apart from the presence of stones are included in the literature:

1. Tumours benign or malignant in or around the ureters (Abeshouse 1956, Altvater 1956, Liefcast & Schimatzek 1957, Wood & Howe 1958).
2. Periureteric endometriosis, an unusual localization of a common condition (Chinn, Hopton & Rusche 1957, Berlin, Waldman, White & McLain 1964).
3. Leukoplakia of the ureters (Falk 1954, Baron 1955).
4. Retroperitoneal fibrosis (Ormond 1948, Bradfield 1953, Chrisholm, Hutch & Bolomey 1954, Iozzi & Murphy 1957, Millard & Wyman 1959).
5. Nonspecific ureteritis, an extremely rare condition (Noring 1958) and tuberculosis (Frimann Dahl 1955).
6. Valves in the ureters, described in only a few cases (Roberts 1956).
7. Imprints on the ureters caused by vessels. These changes may be caused by accessory renal arteries (Weisleder, Emmrich & Schirmeister 1962) or widened collateral arteries due to *renal arterial stenosis* (Isaac, Brem, Temkin & Movius 1957, Thomas & Lewin 1961, Halpern & Evans 1962, Woodard 1962, Berlin & Waldman 1964, Frenckner 1964, Wong & Chow 1964).

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Fig 2 Fg 3

Fig 2 Left en l phlebog aphy in a mult pa a *Left view* at 1 second etrograde flow n a f mm w de ovari n ve n *Right view* at 12 s conds a 6 mm wide ureteric imp nt at th c oss ng s t

Fig 3 U og aphy in a null para A 3 mm w de ureteric mprint (arrow) p obably cau ed by the ros ing left gonadal v in

associated with wide left ovarian veins and pelvic varicosities The imprints had characteristic appearances and were observed only at the crossing site The multiple notches in the ureter of the patient reported by TAYLOR & BOYES are not particularly clear in their illustration The patient had not been examined with s lective renal phlebography in connection with pyelography The authors assumed the vein to be the ovarian vein However with due regard to the course

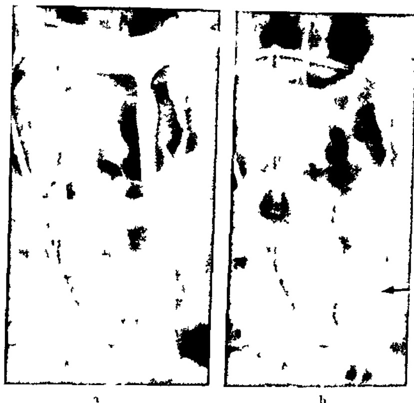


Fig. 1. Left renal phlebography in a multipara. a) At 3 seconds retrograde flow in a 6 mm wide ovarian vein. b) At 30 seconds a 6 mm wide ureteric imprint (arrow) at the crossing site.

observed in the supine as compared to the erect position was the level at which the ureter and the gonadal vein crossed. The crossing site was about one vertebra more caudal with the patient erect as compared to supine and usually occurred at the level of L3 or L4.

Discussion

The abdominal portion of the left ureter lies immediately ventral to the psoas muscle and crosses the gonadal vessels caudal to the middle of the muscle. The gonadal vessels are ventral to the ureter at the crossing and caudal to this *point the blood vessels lie laterally* (RAUBER-KOPSCH); *the crossing thus corresponds* closely to the site of the imprints described. These imprints were observed in 10 women (33 %) which can be considered a conspicuously high figure compared to the statements in the literature. One possible reason for the high frequency is that the material has been selected and comprises only those patients in whom retrograde contrast filling of the gonadal vein was obtained at selective renal phlebography. This back flow is usually

SUMMARY

An imprint on the left ureter at its crossing with the ovarian vein was observed in 10 women This change per se lacks pathologic importance but if the imprint is broad it may indicate widening of the ovarian vein which occurs mostly in women with pelvic varicosities The demonstration of a ureteric imprint in such a patient should indicate selective renal phlebography to verify the diagnosis

ZUSAMMENFASSUNG

Ein Abdruck der Ovarialvene wo diese den Ureter kreuzt wurde in 10 Frauen observiert An sich hat dieser Abdruck keinen pathologisch diagnostischen Wert aber wenn besonders breit deutet er auf eine erweiterte Ovarialvene hin wie sie gewohnlich bei Varikositat der Beckenvenen vorkommt Fall man einen grosseren Abdruck im Ureter findet sollte eine selektive renale Venographie vorgenommen werden

RESUME

Les auteurs ont observe chez dix femmes une empreinte sur l uretere gauche à son croisement avec la veine ovarienn Cette empreinte n a en soi aucune importance pathologique mais quand elle est large elle peut indiquer un elargissement de la veine ovarienne qui existe le plus souvent chez des femmes atteintes de varices pelviennes La constatation d une empreinte ureterale chez ces femmes devrait faire poser l indication d une phlebographie renal selective pour verifier ce diagnostic

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of the vessel, this seems hardly possible, it does not empty into the renal vein but into the veins in the upper pole of the kidney, and the cranial portion of the vein is considerably narrower than the caudal part The latter part lies, as opposed to the usual course of the ovarian vein, medial to the ureter and is not contrast-filled as far caudally as the pelvis The course of the vein is thus not typical of that of the ovarian vein, and the notches do not have the characteristic appearances of the imprints noted in the present material It therefore seems doubtful that the ureteric notches described are caused by the ovarian vein The site of the vein and its overall appearances correspond well with varicose ureteric veins described by e g BERMAN & COPELAND The cranial portion of the vein demonstrated by TAYLOR & BOYES is probably that of a renal pelvic vein, a calculus lay in the ureter None of the imprints in the present material was accompanied by hydronephrosis, hydro-ureter or other pathologic processes in the urinary tract

Despite the fact that the imprints in the present material were situated at the crossing of the contrast filled gonadal veins, the changes could have been caused by the gonadal arteries, since these vessels course together at the crossing of the ureter The fact that the width of the imprints almost exactly corresponded to the diameter of the associated gonadal veins and that they varied in width from 3 mm to 12 mm indicates that the changes were by the vein and not by the artery In an earlier cited report (CHIDEKEL) the width of the gonadal vein has been shown to be considerably increased in the presence of pelvic varicosities This condition occurs mainly among multiparae After repeated pregnancies there is a statistically significantly increased frequency of incompetent valves in the gonadal veins

The ureteric imprints were not observed in the present material at urography performed with ureteric compression and it cannot therefore be stated with certainty if the changes are demonstrable under such conditions A ureteric imprint can also probably be effected by a gonadal vein of normal width The authors have recently noted ureteric 2 to 3 mm wide imprints at the crossing site (Fig 3) in two patients at urography after release of ureteric compression Both patients were young childless women Selective phlebography was not performed in the renal vein and probably would not have provided any additional information since the retrograde contrast passage in the left gonadal vein usually occurs in multiparae with incompetent valves in the ovarian vein

Even if the imprints described lack pathologic importance from a urologic point of view they can give information on the width of the gonadal vein If a wide imprint on the ureter is observed at urography, i e more than 5 to 6 mm wide this finding should suggest the presence of pelvic varicosities and lead to renal phlebography for verification of the diagnosis

SUMMARY

An imprint on the left ureter at its crossing with the ovarian vein was observed in 10 women. This change per se lacks pathologic importance but if the imprint is broad it may indicate widening of the ovarian vein which occurs mostly in women with pelvic varicosities. The demonstration of a ureteric imprint in such a patient should indicate selective renal phlebography to verify the diagnosis.

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Ein Abdruck der Ovarialvene, wo diese den Ureter kreuzt, wurde in 10 Frauen observiert. An sich hat dieser Abdruck keinen pathologisch-diagnostischen Wert, aber wenn besonders breit deutet er auf eine erweiterte Ovarialvene hin, wie sie gewöhnlich bei Varikositäten der Beckenvenen vorkommt. Falls man einen grösseren Abdruck im Ureter findet, sollte eine selektive renale Venographie vorgenommen werden.

RESUME

Les auteurs ont observé chez dix femmes une empreinte sur l'uretère gauche à son croisement avec la veine ovarienne. Cette empreinte n'a en soi aucune importance pathologique mais quand elle est large elle peut indiquer un élargissement de la veine ovarienne qui existe le plus souvent chez des femmes atteintes de varices pelviennes. La constatation d'une empreinte urétérale chez ces femmes devrait faire poser l'indication d'une phlébographie rénale sélective pour vérifier ce diagnostic.

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ANTERIOR MENINGEAL BRANCH OF THE VERTEBRAL ARTERY

by

T GREITZ and T LAUREN

The posterior meningeal artery mentioned in current textbooks of anatomy appears to be the only meningeal branch arising from the extracranial portion of the vertebral artery apart from the meningeal arteries of the cervical dura that has been dealt with in the literature Its radiologic appearance has been described by DILENGE et coll (1965) and HAWKINS et coll (1966) This artery supplies the occipital portion of the posterior fossa dura and the adjacent portions of the tentorium and falx It arises from the main trunk of the vertebral artery between its second bend and the foramen magnum We have however observed another meningeal artery during vertebral angiography and at autopsy which arises more caudad and supplies the upper anterior cervical dura and adjacent structures in the condylar region We have named this artery the anterior meningeal branch of the vertebral artery

Material and Methods Forty out of 125 normal vertebral angiograms were technically satisfactory for a close study of the anterior meningeal branch it was observed in 19 cases The small proportion of satisfactory angiograms may be explained mainly by the facts that the upper cervical area had not

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Fig 2 A p and lateral angiograms from a normal case The anterior meningeal branch is small (←) and in the lateral view is projected close to the posterior margin of the body of the axis (Both vertebral arteries filled because of proximal occlusion on the left side)

specimens up to the level of the foramen magnum where it ended in several small twigs to the dura

The subtraction technique proved helpful in studying this vessel at vertebral angiography especially in a p views The anterior meningeal artery, excepting its proximal part lay inside the spinal canal in both projections (Fig 2) The artery could generally not be traced all the way up to the skull base When filled on both sides it was seen in the a p view (Fig 2a) to follow the same symmetric course as in the autopsy specimens The first part was usually projected in the lateral projection into the second intervertebral foramen and posterior to the first bend of the vertebral artery The remaining distal part always closely followed the posterior aspect of the vertebral bodies and was frequently projected onto the main trunk Due to the normal tortuosity of the vertebral artery the meningeal branch lay both anterior and at the second bend posterior to the main trunk (Figs 2 3 and 4) It was always projected anterior to the anterior spinal artery (Fig 3) The distal part of the anterior meningeal branch continued in three cases through the condyle with a course corresponding to the anterior condylar canal (hypoglossal canal) In one case it anastomosed with the ascending pharyngeal artery to form an arch through the occipital condyle (Fig 4) Connections between the ascending pharyngeal branch of the external carotid artery and branches of the vertebral artery have

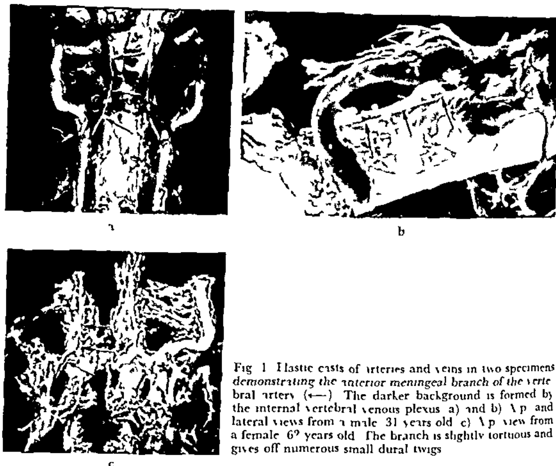


Fig 1 Plastic casts of arteries and veins in two specimens *demonstrating the anterior meningeal branch of the vertebral* artery (←) The darker background is formed by the internal vertebral venous plexus a) and b) A p and lateral views from a male 31 years old c) A p view from a female 62 years old The branch is slightly tortuous and gives off numerous small dural twigs

been sufficiently exposed or had not been included in the films The technique used in most of the cases was direct percutaneous puncture of the vertebral artery, as described by LINDGREN 1950 and modified by SJÖGREN 1953 Two cadavers, in which the vertebral arteries and the vertebral veins had been injected with a viscous *cold* polymerizing *plastic* mixture (WESTBERG *1963*), were available (see GREITZ et coll 1962)

Results and Discussion

The origin and course of the two anterior meningeal arteries were symmetric in both cadavers The artery arose from the main trunk immediately *below* its first bend at the level of the axis (Fig 1) and passed medially through the intervertebral foramen anterior to the dural sheath of the third cervical nerve root and its surrounding veins It then ran upwards and slightly medially in the spinal canal, situated ventrally and closely adjacent to the epidural veins, it gave off several branches supplying the dura It could be followed in both

been reported by RICHTER (1953), WIEDENMANN (1962) SCHECHTER (1964) and NIERLING et coll (1966) but the vertebral branches were not those described in this paper

Pathologic changes in the anterior meningeal artery may be of diagnostic significance as demonstrated by the case of a glomus jugulare tumour illustrated in Fig 5 The main arterial supply was derived from the external carotid artery A significantly dilated and tortuous anterior meningeal artery feeding a small posterior part of the tumour above the condyle was demonstrated at vertebral angiography This region of the mass was not filled from the external carotid artery

SUMMARY

The anatomy and the angiographic appearances of a hitherto unreported anterior meningeal branch of the vertebral artery are described The diagnostic significance of changes in this branch in a case of glomus jugulare tumour is discussed

ZUSAMMENFASSUNG

Es wird uber das anatomische und angiographische Aussehen eines Meningealastes der A vertebralis berichtet der fruher in der Literatur nicht beschrieben worden ist Die diagnostische Bedeutung von pathologischen Veranderungen dieses Astes in einem Falle von Glomus tumor der Vena jugularis wird erortert

RÉSUMÉ

Description de l anatomie et de l aspect angiographique d une branche méningée antérieure de l artere vertébrale qui jusqu a maintenant n avait fait l objet d aucune publication L auteur examine son importance pathologique dans un cas de tumeur du glomus jugulaire

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Fig 3 Lateral view normal case showing the anterior spinal artery (⟵) and the anterior meningeal branch of the vertebral artery (⟵+)





Fig 4 A p and lateral views normal case The anterior meningeal branch (⟵) extends through the occipital condyle (probably through the anterior condylar canal) and anastomoses with the ascending pharyngeal artery (+⟶)





Fig 5 A p and lateral views from a case of glomus jugulare tumour The anterior meningeal branch (⟶) is wide and tortuous and supplies the posterior part of the tumour (+⟶) (The main arterial supply *is derived from the external carotid artery*)

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NEPHROANGIOGRAPHY IN PERIARTERITIS NODOSA

Report of a case

by

FRITZ EFSEN and ULF LORENZEN

Periarteritis nodosa (pan- or polyarteritis nodosa) is a histologically well defined entity among the collagen diseases. The condition is characterized by initial fibrinoid necrosis of the vessel wall succeeded by the formation of granulation tissue with resulting scar-like stenosis of the vessel. The muscular arteries, and only exceptionally the veins, are affected. The lesions may be disseminated or confined to a few organs (DIAZ-RIVERA & MILLER 1946). In some cases only the smaller arteries and the arterioles may be involved. Palpable thickening along the arteries may be present, as indicated by the name (KUSSMAUL & MAIER 1866). The diagnosis can, however, be determined only histologically.

Numerous reports have appeared on the macroscopic and microscopic lesions which are almost uniform in all organs (GRUBER 1925, ARKIN 1930, DIAZ-RIVERA & MILLER). Reports on the angiographic findings are few, however. BRON, STROTT & SHAPIRO (1965) published the first case of periarteritis nodosa in which abdominal aortography was performed. FLEMING &

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F g 2 Nephrogr ph pl se The contrast load ng is heterog ne s

The nephrographic loading (Fig 2) was very irregular areas of normal contrast density alt rnating with others of sl ght or no loading By superposition the loaded areas were found to be vascularized even if the arteries were abnormal Only few or no arteries were present in the ar as of no loading As the size and shape of the kidney were normal and no typical tumour vessels were evident a new growth was considered unlikely No radiologic diagnosis was made

The serum creatinine rose from 0 7 to 1 4 mg per 100 ml and a daily protein urea of 5 g was recorded at the time of renal angiography The urine contained no c lls or cylinders

Renal b opsy was not performed because of the severe hypertension and poor general condition Hepatic biopsy previous to the hypertensive crisis had indicated acute hepatitis while skin and muscle biopsies were normal

Shortly after the recording of hypertension a pericardial rub was heard and transitory ECG changes indicating myocardial infarction of the anterior wall were recorded The hypertension was partly controlled by antihypertensive medication As periarteritis nodosa was now the most likely diagnosis the pati ent was given glucocorticosteroid (prednisone) As no improvement was noticed a cytotoxic agent (imuran) was added The treatment proved ineffective however and the patient died from cardiac and renal insufficiency 67 days after admission

Autop y The kidneys measured 12 cm × 5 cm × 4 cm The capsules adhered to a very irregular surface with numerous slightly elevated infarctions surrounded by narrow red zones the infarctions reached the papillae and were separated from one another by dark areas The renal arteries were macroscopically normal No specific changes were apparent in any other organ The brain was also normal

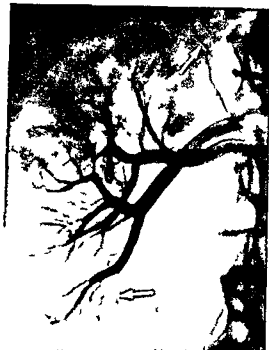


Fig. 1. Selective injection into right renal artery, early arterial phase. The renal artery and primary branches were normal on both sides but the peripheral arteries were fewer and shorter than normal. The adrenal artery and some of the arteries in the lower pole are constricted in parts (arrows).

Stern (1965), Chudacek (1966), and Kincaid (1966) have provided three more cases.

The characteristic *radiologic findings in the visceral type of the disease* are arterial aneurysms and rarefaction of the smaller arteries, particularly in the kidney and intestine. The vascular changes tend to differ from one case to another.

Case report

A male aged 37 was admitted for collagen disease with abdominal pain, vomiting, extreme loss of weight and slightly raised temperature. When 10 years old he had suffered from uncomplicated rheumatic fever; no history of arterial hypertension or renal disease. The arterial blood pressure was normal but after a month the patient developed arterial hypertension accompanied by repeated general convulsions. Left side carotid angiography furnished no explanation for the convulsions. Ophthalmoscopy revealed fundus hypertonicus grade I.

As urography suggested changes in the right kidney, nephroangiography was performed with injection of Urografin 60 % through a catheter introduced from the right femoral artery.

Nephroangiography. The renal arteries and primary branches turned out to be normal on both sides, whereas the peripheral arteries were fewer and shorter than normal. This was particularly evident after selective injection into the right renal artery (Fig. 1). Some of the arteries of the lower pole had long dilatations and short constrictions, and similar changes were seen in the right adrenal artery. An aneurysm was present in an interlobar artery in the lower pole.

case whereas both cases had rarefaction of the peripheral arteries It is probable that the periarteritic process has been demonstrated in different phases and that the incidence of aneurysm formation may vary from one case to another

A heterogeneous nephrogram was produced in all the cases including the present one and may be explained as a result of arterial stenosis accompanied by changes in the hemodynamic function of the arteries

Conclusion

Nephroangiography in this case of periarteritis nodosa was performed shortly after the development of signs of marked arterial hypertension and renal damage The observations correspond to those previously published and probably indicate active vasculitis

SUMMARY

The angiographic appearances of the kidneys in a case of periarteritis nodosa are described The various stages of the condition with special reference to pathologic features are discussed

ZUSAMMENFASSUNG

In einem Fall von Periarteritis nodosa wird das angiographische Bild der Niere beschrieben Die verschiedenen Stadien der Erkrankung und ihre pathologischen Erscheinungen werden erörtert

RÉSUMÉ

Description de l aspect angiographique des reins dans un cas de périartérite noueuse L auteur étudie les diverses phases de cette affection en particulier au point de vue anatomo-pathologique

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Histologic examination The arteries of the kidneys and the striated muscles had wide spread scar like thickenings with stenosis and even complete occlusion Numerous anemic infarctions surrounded by reactive zones of very few cells were present in the kidneys Fibrinoid necrosis was not evident The histologic diagnosis was periarteritis nodosa in a late partly healed phase

Discussion

According to Arkin (1930) there are four stages of periarteritic involvement of vessels In the first stage subendothelial oedema and fibrinoid necrosis are present but there is no clinical evidence of the disease In the second stage the vessel wall is infiltrated by polymorphonuclear leucocytes including eosinophiles, and occasionally lymphocytes and plasma cells The polymorphonuclear cells disappear in the third stage and the vessel is infiltrated by granulation tissue, which may give rise to thrombosis and occlusion Aneurysms are often formed in this stage and may cause perirenal hematomas (Ostrum & Sodei 1960) Finally the vessel in the last stage is transformed into a scar, the noduli along the larger arteries described by Kussmaul & Maier are formed in this stage The involvement does not proceed synchronically in all arteries within the same organ Acute inflammation and scar formation were present in the renal vessels in one of the cases reported by Griffith & Vural (1951)

Lesions in the kidneys are often seen at autopsy Arkin (1930) and Rose (1957) reported an incidence of about 80 per cent Anemic infarctions caused by arterial occlusion are most frequently seen The glomeruli may however be involved separately Renal insufficiency is therefore a common cause of death in periarteritis nodosa (Ralston & Kvale 1949) Albuminuria microscopic hematuria, and cylindruria are present in nearly all cases with renal involvement Rose (1957) stated that arterial hypertension was evident only when the renal arteries were considerably involved

The present case had moderate albuminuria, slightly increased serum creatinine, and severe hypertension, when nephroangiography was performed The radiologic appearances of the renal arteries correspond well to the above pathologic findings It is probable that the involvement was partly in the stage of granulation and partly in the stage of scar formation, as areas with irregular arteries lay between areas with practically no vascularization An exact determination of the stage is not possible, as no renal biopsy was done

A comparison of three of the four cases hitherto published and the present case indicates that the formation of aneurysms may prevail, as in the reports of Bron et coll , Kincaid, and Fleming & Stern No aneurysms were apparent in the case published by Chudacek, and only a few in the present

case whereas both cases had rarefaction of the peripheral arteries It is probable that the periarteritic process has been demonstrated in different phases and that the incidence of aneurysm formation may vary from one case to another

A heterogeneous nephrogram was produced in all the cases including the present one and may be explained as a result of arterial stenosis accompanied by changes in the hemodynamic function of the arteries

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ANOMALOUS PULMONARY VENOUS DRAINAGE TO BELOW THE DIAPHRAGM

by

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Anomalous pulmonary venous drainage to below the diaphragm is a rarity Our material of 1 500 congenital malformations of the heart and great vessels examined by cardiac catheterization and angiocardiography contains only five such cases and less than 100 cases are described in the literature These malformations have however certain characteristic radiographic features that make them recognizable in standard chest roentgenograms and a brief report of the cases may therefore be justified

The most common form is the abnormal drainage of the right lung into the inferior vena cava or into the junction of the latter with the right atrium This malformation of the pulmonary venous system is associated with hypoplasia of the right lung and frequently with anomalies of the bronchial tree secondary dextro positioning and rotation of the heart and underdevelopment of the right hemithorax Hypoplasia of the right pulmonary artery and anomalous systemic arterial supply to the lower lobe of the right lung from the aorta or its branches are also sometimes present NEILL et coll (1960) have coined the term scimitar syndrome for this complex of malformations Sixty three cases of the scimitar syndrome have been described (ROEHM JUE & AMPLATZ 1966) and four additional cases have been observed at our centre The age varied from 13 to 21 years two of the

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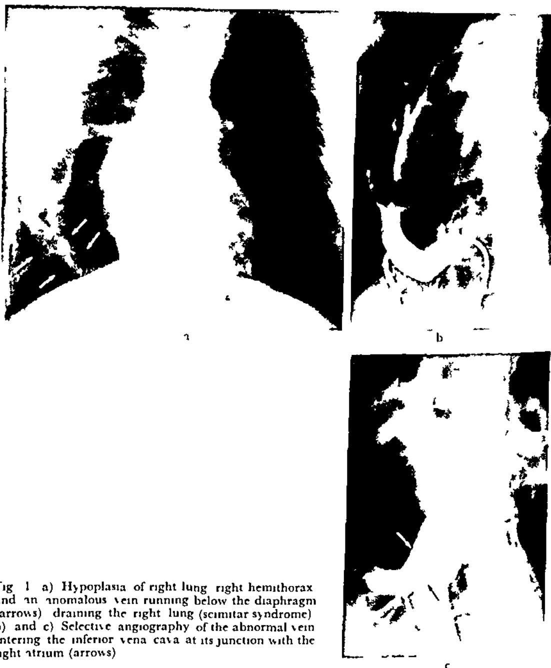


Fig 1 a) Hypoplasia of right lung right hemithorax and an anomalous vein running below the diaphragm (arrows) draining the right lung (scimitar syndrome) b) and c) Selective angiography of the abnormal vein entering the inferior vena cava at its junction with the right atrium (arrows)

subjects were males and two females Only one of them had marked symptoms to indicate a left to right shunt, the others had no or only slight subjective symptoms

All the cases presented appearances in the conventional chest roentgenogram typical of the scimitar syndrome In three of them the hypoplasia of the right lung *was only moderate and the abnormal vein ran parallel to the right* contour of the heart to disappear below the diaphragm (Fig 1a) More marked hy



Fig 2 a) Hypoplasia of the right lung The abnormal vein is partially projected within the contour of the heart (arrows) b) Oblique view A muscular septum separates the right lower lobe from the rest of lung (arrows)

poplasia of the right lung with displacement of the heart was evident in one case in which the abnormal pulmonary vein terminated below the diaphragm and was projected in the a p view partly within the contour of the heart (Fig 2a)

Cardiac catheterization and angiocardiography were performed in all the cases and revealed a considerable shunt to the inferior vena cava into which the abnormal vein from the right lung drained An atrial septal defect was also present in one of the cases whereas in the other three cases no intracardiac malformations were evident Angiocardiography was performed by injection of contrast medium into the pulmonary artery in two cases but in the other two selective angiography of the abnormal vein from the inferior vena cava was preferred (Fig 1b) This seems to be the best way in these conditions to demonstrate the anatomy of the pulmonary veins

Injection into the right side of the circulation will usually show any anomalous arterial supply from the abdominal aorta to the right lower lobe If adequate filling of the aorta is not obtained by this method aortic injection should also be performed Only one of the present cases had an anomalous arterial supply to the lower lobe

One of the cases had an anomaly apparently not previously observed This consisted of a muscular septum separating the right lower lobe from the right upper and middle lobes (Fig 2b) This septum had the appearance at operation



Fig 3 Pulmonary congestion pleural effusions and a density to the right of the heart (arrows) confirmed at autopsy to be an anomalous venous trunk draining both lungs and terminating below the diaphragm

of an extra diaphragm but when seen in the chest films was thought to represent pleural thickening It is interesting to note that the arterial supply of the right lower lobe was normal in this case

The scimitar syndrome may be diagnosed practically always in ordinary chest roentgenograms (Figs 1 and 2) The diagnosis may however apparently be difficult in children, especially in those with malformations of the right lung and inflammatory changes added to those caused by the anomalous vein *It* seems probable that a number of these cases remain undiagnosed, particularly those in which the anomalous vein drains only the lower and middle lobe of the right lung and in which consequently the left to right shunt is small and no cardiac symptoms are present Cardiac catheterization and angiographic examinations are of course necessary to confirm the diagnosis in cases of possible scimitar syndrome

Total anomalous pulmonary venous drainage with connection below the diaphragm is a more rare malformation Only 34 such cases have been described in the literature (Lucas et coll 1961, 1963, Keats et coll 1965) This malformation produces serious effects in the first weeks of life and most of the cases reported have been fatal The only patient we have observed with this malformation was taken to hospital when he was three weeks old, after a week of dyspnea and fever Chest films revealed congestion of the lungs and bilateral pleural effusions, in addition to a change in the right lower hemithorax lateral to the heart (Fig 3)

The patient was given antibiotics and was digitalized and improved for a few

days Angiocardiography was planned when the child suddenly developed cardiac arrest and died At autopsy the pulmonary veins from both lungs drained into a wide channel lateral to the right contour of the heart and corresponding to the change seen in the chest roentgenogram This venous channel emptied below the diaphragm into a network of veins to which the portal vein the hepatic veins and the umbilical veins were also connected This network also communicated with the inferior vena cava

This malformation of the venous system has apparently not been described before It corresponds to the early developmental stage when the pulmonary veins via a rete of veins are connected with the cardinal veins and the umbilicovitelline venous system (NEILL 1956) In most of these cases the drainage has been directly to the portal vein and in five cases to the inferior vena cava (COOLEY & PANAYOTIS 1962) Radiographic diagnosis with ordinary chest films is difficult since it is rare for the anomalous venous trunk to be visible outside the contour of the heart in a p films as in the present case HARRIS et coll 1960 and others have stressed the significance of pulmonary congestion with interstitial collection of fluid in the lungs and bilateral pleural effusions in combination with a normal or only moderately enlarged heart Angiocardiography in such a case will provide a definite diagnosis and since the malformation may be corrected surgically (COOLEY & PANAYOTIS 1962) the often poor clinical condition of the child should not prevent such a diagnostic procedure

Addendum in proof

Two additional typical cases of scimitar syndrome have been observed in our department during the last six months Both patients were women 19 and 21 years of age respectively They had symptoms of a left to right shunt and abnormal venous drainage of the right lung into the inferior vena cava but no other cardiac abnormalities

SUMMARY

Five cases of anomalous pulmonary venous return below the diaphragm were discovered in a material of 1 500 cases making a total of less than 100 cases reported in the literature In addition to the anomalies described *one of the cases* had a muscular septum separating the right lower lobe from the rest of the lung and one case had a complicated malformation of the infra diaphragmatic venous system

ZUSAMMENFASSUNG

Ein abnormaler Abfluss der Pulmonalvene unterhalb des Zwerchfelles wurde 5 mal in einem Material von 1 500 Fallen angetroffen Dies bringt die Gesamtzahl der beschriebenen Falle zu unter 100 Zusatzlich zu den obigen Veranderungen hatte ein Fall eine Muskelschicht die den rechten Unterlappen der Lunge von der ubrigen Lunge abtrennte und ein anderer Fall hatte eine komplizierte Missbildung der unteren Korpervenen

RESUME

L'auteur a trouvé cinq cas de retour veineux pulmonaire anormal au dessous du diaphragme sur 1 500 cas ce qui fait un total de moins de 100 cas publiés. Outre les anomalies décrites, l'un de ces cas avait un septum musculaire séparant le lobe inférieur droit du reste du poumon et un cas présentait une malformation complexe du système veineux sous diaphragmatique.

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PHOTOGRAPHIC PROCEDURE IN CINEROENTGENOGRAPHY

by

OVE MATTSSON

Cineroentgen film cannot be viewed directly but must be studied with a projection equipment The photographic procedure between the radiographic exposure and the study of the projected image may be varied in different ways the currently available approaches being (1) use of only the primary roentgen negative for a reduced scale positive print or (2) use of the negative for study without any printing procedure

The employment of 35 mm film as a roentgen negative and later copying of this film to a positive print on 16 mm film for study is a generally accepted procedure Projection with a 16 mm projector is held to be a useful method and special projectors are available These factors may have influenced the selection of this technique For demonstrations to large groups 16 mm film has been considered to be the best solution

The need for copying is also much influenced by the fact that the first negative is often developed in such a manner as not to be entirely suitable for direct viewing the contrast may for example be too low

Much attention has been given to the question of photographic grain

Submitted for publication 26 October 1966

RESUMÉ

L'auteur a trouvé cinq cas de retour veineux pulmonaire anormal au dessous du diaphragme sur 1 500 cas, ce qui fait un total de moins de 100 cas publiés. Outre les anomalies décrites, l'un de ces cas avait un septum musculaire séparant le lobe inférieur droit du reste du poumon et un cas présentait une malformation complexe du système veineux sous diaphragmatique.

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FROM THE ROENTGEN DEPARTMENT (DIRECTOR PROF ERIK LINDGREN) SERAFIMERLASARETTET, STOCKHOLM SWEDEN

PHOTOGRAPHIC PROCEDURE IN CINEROENTGENOGRAPHY

by

OVE MATTSSON

Cineroentgen film cannot be viewed directly but must be studied with a projection equipment The photographic procedure between the radiographic exposure and the study of the projected image may be varied in different ways the currently available approaches being (1) use of only the primary roentgen negative for a reduced scale positive print or (2) use of the negative for study without any printing procedure

The employment of 35 mm film as a roentgen negative and later copying of this film to a positive print on 16 mm film for study is a generally accepted procedure Projection with a 16 mm projector is held to be a useful method and special projectors are available These factors may have influenced the selection of this technique For demonstrations to large groups 16 mm film has been considered to be the best solution

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Fine grain film for the first negative exposure has been said to be essential, the reduced contrast generally appearing in fine grain emulsions is more marked when the processing is selected with the small grain in mind. An improvement in contrast is possible with subsequent copying, however. It has also been considered that copying should demand a smaller dose of radiation. This point of view is difficult to understand, as all films need a certain amount of exposure for optimum density and contrast. No method of restitution for an underexposed image is available and copying can only to some extent change the general impression of the image. Furthermore, each step of copying means a loss of detail. Rapid film emulsion with low contrast might be copied with an increase in contrast but no real additional information can be obtained. It has also been stressed that copying may compensate for exposure errors made in the primary exposure but an improperly exposed film can never be restored. All cine roentgenographic units have control systems for the exposure, which makes optimum exposure easy to obtain and exposure errors few.

Roentgen diagnostics has developed beyond the sole presentation of anatomic details. To day a more physiologic approach is desirable and it has been made possible by the advances made in motion studies. It is most important that cineroentgenographic films be processed as rapidly as films from ordinary roentgen examinations so that they can be studied without delay. The loss of time in copying cinefilm is considerable, and the extra cost is appreciable.

From the practical point of view it is thus desirable to utilize the same principles and apparatus that are available for routine roentgen films. Roentgen films can now be ready for viewing in a relatively short time after exposure. Similar demands seem justified in the case of cinefilm.

Experiences with a simple processing technique for 35 mm roentgenographic cinefilm suited for direct use of the primary negative will now be presented. The use of 16 mm film for the primary exposure, or any type of reversing process, will not be discussed, however.

The same principles as for conventional roentgen films are applicable in general to the processing of cinefilm. It is desirable to use a film emulsion of high contrast in order to compensate for the lower absorbtion differences of higher kilovoltages — today up to 150 or 200. A developer that utilizes the maximum available contrast of the emulsion is needed and although the types of photographic emulsion may vary, a developer for roentgen film should be practical. An important consideration with high gamma developer is the photographic grain, and some tests have been made in order to determine its true importance. The same 35 mm cinefilm, with an emulsion of high speed and contrast, was used for roentgencinematography with an image amplifier for depicting the same object as projected optically in an ordinary camera

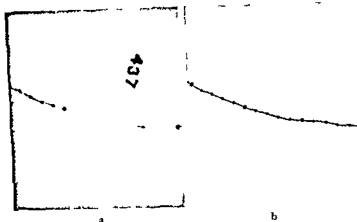


Fig. 1. a) Roentgenogram with considerable graininess caused by radiographic quantum mottle. b) Image made by visible light of same object and same film which was identically processed; this has hardly any photographic grain.

The object, a wire with small metal balls, was represented in the same scale. Both films were then processed together in a roller machine with the ordinary roentgen developer. The results are given in Fig. 1.

The experiments disclosed a visible graininess in the radiographic image, but this was practically absent when the same film had been used in a similar manner but the image not produced by roentgen rays through an image amplifier but merely by visible light. The striking graininess in the radiographically produced image is explainable by the radiographic quantum mottle. The grain of the photographic emulsion is thus in itself fine enough for each radiographic purpose. The advantage of a further reduction of the photographic grain size of the cinefilm is therefore of little importance for the final image. The developer used in this test was, like all roentgen developers, an active one which is not at all favourable as regards graininess but most satisfactory from the viewpoint of contrast.

The author considers that from the practical aspect the question of photographic graininess may be disregarded when 35 mm cinefilm is used. This is interesting in view of the great attention that has been focussed on grain. A possible explanation is the fact that radiographic quantum mottle has been confused with the true photographic grain.

The quantum mottle in roentgenograms has been given much attention in recent years (ROSSMANN 1963, 1964 and 1965). Its influence upon the radiographic image may be considerable and especially striking with the new high

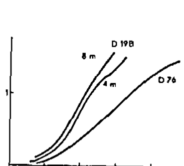


Fig 2 Density curves for Kodak Cineflure film processed in some standard developers Curves corrected for fog (From De Oude Delft 1963)

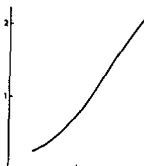


Fig 3 Density curve for Kodak Cineflure film developed in a processing unit (roller machine) with ordinary roentgen film developer

gain amplifiers, with which the primary radiographic exposure can be held extremely low

The quantum mottle is directly related to the amount of exposure Low sensitive emulsions with fine photographic grain always record a more frequent and thus more 'homogeneous' mottle compared with high sensitive emulsions The former also possess a low contrast, which reduces the degree of visibility of the mottle pattern

The properties of a film material and the photographic contrast recording quality may be determined from the density curve (D log E curve) Density curves for the film used in the above experiments are given in Figs 2 and 3 The curves in Fig 2 represent some recommended standard developers and varied processing times For comparison, the density curve obtained with the same film developed in the roentgen developer of the present experiment is shown in Fig 3 The latter, the roller machine developer, gives a photographic result rather similar to that obtained with a common high contrast developer The employment of a roentgen developer thus entails no essential photographic disadvantage

Extensive experience in developing cineroentgenographic film in conventional roentgen developers was gained in a manual processing technique used for several years in Roentgen Department F of Karolinska Sjukhuset The film was introduced into the developing tank directly from the cassette spool Its first part was fastened to the edge of the developer tank and the film was slowly and carefully placed in the tank in large loops The introduction of the film into the bath was made at a given and constant speed, 100 feet of film requiring about 2 minutes This technique requires large tanks, 200 feet of film could be developed in a square tank of 120 litres The solution had first



Fig. 4. Light tight box for use with the processing unit.



Fig. 5. Winding up arrangement for cinefilm.

to be well stirred and when the development was completed the film was brought over to the fixing bath having passed first for a few seconds through a tray of clean water. The film then left the developer at the same speed at which it was introduced so that the whole of it was equally developed. This simple method involving use of the tanks available for conventional roentgenograms gave good results. The only extra departmental equipment required was a large winder for drying the processed film.

Development with an ordinary processing unit with rollers may be performed without difficulty. The Pacoroll developing machine with rollers has been used for about three years in our department to process all 35 mm cineroentgen film. A technique introduced by HORENSTEIN (1963) in connection with processing miniature film for slides has been used for introducing the cinefilm into the machine. A small piece of ordinary roentgen film (9 cm × 12 cm) acts as a feeder and with this the cinefilm is brought emulsion side down into the receiving end of the developing unit. The cinefilm is fed into the machine from a special light tight box (Fig. 4) fitted with a narrow canal in the shape of a flat tube through which the film leaves the box. The tip of the tube is of soft black plastic which can be put into the machine without a gap so that the ordinary darkroom lighting cannot fog the film. It is placed close to the left or right side of the slit for introducing films and does not influence the simultaneous processing of the routine roentgen films. The ordinary chemicals recommended by the manufacturer are used in the processing unit. The speed with which the cinefilm is taken through the machine is 20 inches a minute, the total processing time being 8 minutes. A preliminary evaluation

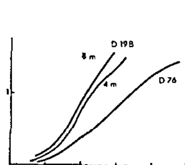


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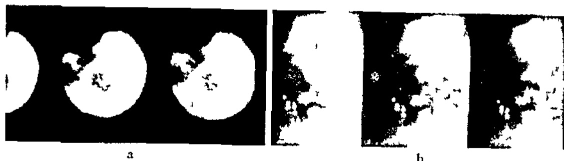


Fig 6 a) Part of a 16 mm cinefilm copy made with an intermediate negative b) The frames have been enlarged in printing

of the dry film can then be made That part of the film that is first visible is usually the part last exposed The entire film is usually exposed with about the same adjustment and each part of the film will generally be equally exposed, the general experience has been that the exposure quality of the first segment of the film will be representative of the remainder An arrangement to wind the emerging film under constant and fairly strong tension prevents it from travelling obliquely and eliminates curvatures, this device has been built by Philips to our design (Fig 4) The washing might be made easier with cinefilm than with the standard roentgen film, which generally has a much thicker emulsion, hardening factors may naturally play a role It is well known that the chemicals must often be adapted to some types of film

Experiences with this method of processing have been encouraging Since the complete developing process requires so little time, correction of errors in exposure are possible while the patient is still in the department A significant advantage is that no special apparatus nor personnel is necessary One disadvantage, possibly of minor importance, has however been encountered Some types of cinefilm have proved to be less heat resistant than others, probably due to less hardening in the manufacture, and have then been damaged in the drying section of the unit By switching off the heat for drying it is possible to obtain an undamaged but incompletely dried film from which the remaining water can be removed by an electric fan at room temperature A somewhat prolonged but entirely adequate procedure can be arranged for emulsion of such sensitivity and this means a free choice of the type of film

Processing of cinefilm in the manner described constitutes the proper photographic solution and is acceptable from the clinical aspect The films have an optimal contrast for direct study As there is no need for such extra processing equipment or procedures as were previously considered necessary, the introduction of cineroentgenography for medium sized and small roentgen departments may now be accelerated

Only a few routine cineroentgenographic films will usually have to be viewed at other times than at clinical demonstrations or when writing reports Large amounts of film have no scientific value and there is no reason for extensive and expensive reduction to 16 mm Furthermore the recent introduction of a new principle of projecting 35 mm cinefilm both for individual studies and for large audiences (MATTSSON) reduces the need for copying to an absolute minimum Copying may naturally be necessary in certain instances for example by printing with the help of specialized equipment A detail in a frame may be enlarged to an arbitrary scale Adequate balancing of the light in copying needs experience and automatic laboratory equipment that can only be made available in a hospital at very high costs An uncomplicated unprofessional manner of copying cannot do full justice to a film which is to be joined to a 16 mm film for demonstration at congresses for example

The proper way to copy is to utilize an intermediate positive film (35 mm) which later on can be reduced to 16 mm The advantages of having such a master positive are many The final 16 mm copy will have a distribution of black and white in every respect equal to the original film a not unimportant factor There are certain reasons for having a cineroentgen film looking like a series of ordinary roentgenograms An intermediate positive on 35 mm film produces only a small loss of detail through two step copying and the positive forms a good base for special variations in the copying procedure e g printing This intermediate positive is ordinarily made with poor contrast with the final copy again at full contrast The positive can be stored in archives so that film copies equal to the first one can always be made Another advantage of having an intermediate positive is that it can be used for making paper prints of separate frames

An example of copying with an intermediate positive film appears in Fig 6a Another series of frames are represented in Fig 6b showing enlargement by printing to blow up certain details in a 16 mm copy of calcifications of the heart Lead balls were used as indicators

SUMMARY

The development of cineroentgen film in an ordinary processing unit without greater inconvenience is described Such a procedure is time saving and may perhaps help to further the use of roentgen cinematography in diagnosis

ZUSAMMENFASSUNG

Es wird gezeigt wie Cinerontgenfilm in einer gewöhnlichen Entwicklungsmaschine ohne grössere Komplikationen entwickelt werden kann Die Methode ist zeitsparend und könnte wohl die Cinerontgenographie popularer machen

RÉSUMÉ

Description du développement du film cinéradiographique dans une machine à développer ordinaire sans difficulté notable Cette technique fait gagner du temps et contribuera peut être à faire employer plus largement le radiocinéma pour le diagnostic

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— Some physical factors affecting image quality in medical radiology J Phot Sci 12 (1964) 279

FROM THE ROENTGEN DEPARTMENTS OF ERSTA SJUKHUS AND KAROLINSKA SJUKHUSET STOCKHOLM SWEDEN

BARIUM CONTRAST AGENTS

by

GUNNAR EMBRING and OVE MATTSSON

The purpose of the investigation was to determine whether barium contrast media employed in roentgen diagnostics could be improved particularly as regards stability and rendering of detail

All the contrast media available to the authors were first tested and various brands and grades of $BaSO_4$ among them a sample described as colloidal barium sulphate were examined by microscopy It turned out that the majority had a considerable tendency towards aggregation i e flocking together of the separate particles The one described as colloidal had a lower such tendency however but its particles were so large that the term colloidal was not justified the diameter of the individual particles varied widely, up to approximately four times A comparison of other commercial preparations revealed that the elementary particles in the main were of the same size throughout

The studies indicated that the aggregation tendency not the size of the elementary particles determined the quality of the suspension Subsequent investigations therefore came to deal less with factors increasing the viscosity but more concentrated on the tendency towards aggregation The conditions prevailing in suspension with other components were also subjected to study The usual method of improving suspension stability seems to be to increase

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Fig 9 Roentgen examination of stomach Because of the low miscibility of the contrast agent with the liquid phase of the mucosa the examination failed in giving a clear representation of the mucosal relief

not to any great extent controllable during the process of manufacture though decrease in aggregation and increase in suspension stability largely appear to accompany each other

The electron miscroscopic studies are presented in Fig 1 which shows a selection of preparations enlarged approximately 8 300 times The aggregates are often quite impressive while the individual particles are of the same general magnitude The result of these studies is somewhat unexpected So-called colloidal barium sulphates do not warrant the name a fact mentioned by HODGES (1953)

Many additives of the traditional type i e those increasing the viscosity remain untested and await trial Vegetal drugs have long been used for stabilizing purposes and there seemed to be good reason for supplementing the experience gathered from commercial preparations with results from new variants A start was made with drugs mixed with chemically pure barium sulphate These included karaya gum sterculia gum guar gum carragheen tragacanth and alginates Dosages of suitable concentrations were prepared in vitro with each one of these additives and the finished compounds were each tested in a few cases referred to the roentgen department for gastrointestinal examination

The estimation of the quality of the contrast medium was of course subjective like all evaluations of this kind but normalization of the tests was possible because comparable examinations with a standard agent (Umbaryt) were always made in the same clinic Comparisons could even be made of one and the same case in many repeat examinations e g of ulceration cases Rating



Fig. 1. Electron microscopic recordings of five different barium contrast agents (commercial). Great similarity in size of the elementary particles but variations in aggregation tendency. × 8 300.

the viscosity by various additions, as known from the literature the following common additives may be mentioned: gum arabic, agar, pectin, starch, gelatine, casein, and cellulose derivatives. The additives have remarkably often been kept secret, and in some cases an analysis has shown the declaration to be incorrect, as was stated e.g. by HODGES (1953).

The tests made with commercial preparations as well as the microscopic investigations left the impression that the size of the elementary particles is

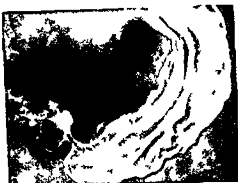




Fig 4 Examination of the stomach with the new contrast medium Normal case

the technique used The practical consequences of these facts have been that the majority of the cases examined with the carboxy methyl cellulose additive had to be examined anew with the standard contrast medium in order to obtain an acceptable result

The results obtained with methyl cellulose were similar This compound was discussed in connection with intestinal studies by MARKS (1961) Dextrans in various molecular weights (from 200 000 down to 15 000) were also tested These preparations were comparatively stable in suspension but had less of the qualities suitable for mucosal relief studies

A few more compounds of a type similar to those mentioned were also tested polyvinyl pyrrolidone and sephadex both proved to give an inferior relief rendering and this also applied to polyvinyl alcohol

Since the high molecular organic compounds examined gave no clue to the solution of the problem of attaining satisfactory suspension stability combined with good mucosal rendering it was decided to test inorganic gel forming compounds as stabilizing additives Bentonite (aluminium silicate) was tried fairly thoroughly but this substance possessed no clear advantage Similar results were obtained with calcium silicate Aluminium hydroxide seems to have been considered as early as 1938 (WOLDMAN) but no indications of its practical use could be found in the literature

Since the relief rendering of the mucosa had been so defective with the additives earlier used an exhaustive study of the potential value of wetting agents was commenced It is true that the principal problem in this connection is not to produce a wetting effect but to make two water phases miscible Wetting agents may in principle increase the miscibility provided the mucus has a low surface tension which is probably the case Tests were made with most of the preparations mentioned and mixing them with Tweens sodium



Fig 3 Practical demonstration of the rheologic transformation of a barium sulphate suspension by additives The highly viscous suspension in (a) becomes quite thin after a small quantity of dry powder has been stirred into it (b) and can then be poured into a second vessel (c)

by points was not possible but classification in groups of 'better', 'worse and 'equally good' was practised The essential question was whether improvement, as compared with the standard contrast material, was possible This was never the case In isolated instances the preparation was judged as possibly of the same class, but practically always as inferior It was further observed that different batches of vegetal drugs could produce differing results and this observation goes well with the experience related to commercial preparations The latter may vary from one batch to another, due partly to the fact that there are practically no standards for these natural products

A compound which is of interest from its use in other roentgenographic procedures is the sodium salt of carboxy methyl cellulose This product can be chosen with a suitable molecular weight and has been recommended by some authors (Kirsch & Spellberg 1953, Hodges 1953) The present authors found however that a product useful in practice could not be obtained The increase in viscosity caused by the carboxy methyl cellulose was such that the miscibility of the viscous contrast agent with any liquid phase remaining on the mucosa was impaired, and the relief pattern, which is so valuable in roentgen diagnosis, could not be demonstrated This is illustrated in Fig 2 The results differ to some extent from those reported for carboxy methyl cellulose by some authors, and we feel that the Swedish examination technique, which is largely based on a study of the mucosa, is more exacting With cinefluorography, the disadvantage hardly appears to be decisive, which seems to indicate that the evaluation is largely determined by the degree of advancement in



Fig 7 Examination of the colon with the new contrast medium Normal case



Fig 8 Roentgenograms from an examination of the hypopharynx with the new contrast medium

the citric and tartaric salts of sodium, potassium and ammonium and the ethylene diamine tetra acetic acid (EDTA) salt of sodium The test series in vitro indicated that sodium citrate produced the best suspension stability A high degree of stability was generally obtained with these salts and the reason seems to be a complete transformation of the structure of the suspension which counteracts the tendency towards aggregation As early as 1908 GENGOU used a citrate to affect suspensions he worked with barium sulphate as a model substance for the study of small solid particles suspended in a liquid, the principal purpose of the experiments being to study suspension stability in blood Sodium citrate was used by SPILLER (1848) for analytic purposes to prevent aggregation

The effect of sodium citrate proved to be substantially intensified by sorbitol This action which is on the molecular level will be discussed separately by the authors in a chemical journal sodium citrate and sorbitol will combine to form organic glass The striking result of adding sodium citrate and sorbitol to a suspension of barium sulphate in water may be illustrated by the following simple experiment Barium sulphate 100 g and water 40 g are



Fig. 5. Examination of the small intestine with the new contrast medium. Normal case.



Fig. 6. Examination of the small intestine with the new contrast medium in a case of Whipple's disease.

lauryl sulphate and saponins. A foam that tended to hamper the evaluation of mucosal detail was usually produced, and this disadvantage overshadowed the somewhat improved miscibility with the mucus layer. The positive attitude towards wetting agent additives, advanced among others by KRAMER (1956), is therefore not shared by the present authors. The experience collected at this stage indicated that high viscosity was rather a disadvantage and that stability had to be secured by other means. Low viscosity and good stability, in spite of a high barium content, seems to be the desirable combination.

An interesting observation was made in the course of the investigation regarding the employed barium sulphate. This had been imported from various manufacturers and was stated to be pure. One sample possessed a *remarkable degree of suspension stability though without additives*. It was described as chemically pure barium sulphate and labelled as neutral. Analysis later on revealed, however, that it contained a small quantity of sodium citrate (about 1 per cent) as an impurity. This unexpected finding prompted the employment of small quantities of certain electrolytes as additives, it was thought that these might affect the aggregation of the particles in the suspension.

A series of tests was begun with the primary purpose of testing the effect of an addition of salts of various multibasic organic acids. The salts included



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Fig 9 Roentgenograms from an examination of the esophagus with the new contrast medium

stirred to the consistency of a thick paste Adding a mixture of sodium citrate 1 g powder and 9 g sorbitol to the paste, the whole will after stirring liquify so that it can be poured into another vessel (Fig 3) A phenomenon of this nature, familiar in connection with colloids, is called peptization This term has sometimes also been used for suspensions to describe their transformation from a 'coagulated' state into a free state The sulphate ions on the surface of the particles, which exist in a high degree of hydration, are pushed aside by the non-hydrated citrate ions This results in liberation of water which will form the homogeneous phase in the suspension

The first results from experiments with building up of a contrast medium based on this principle were presented by EMBRING & MATTSSON (1955) This interesting method of changing the characteristics of a suspension was used by the authors in the development of a preparation for facilitating the evacuation of the large intestine by changing the consistency of the faeces (Microlax,

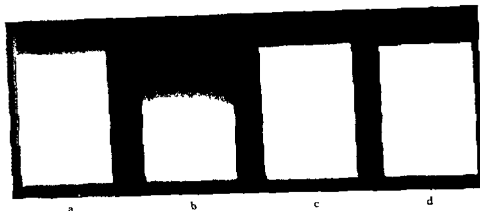


Fig 10 Suspension stability after 2 hours Three commercial preparations (a b c) are compared with the new preparation (d)

Index U S A Mikroklist Germany) A thin barium sulphate suspension with an addition of sodium citrate and sorbitol can absorb considerable additional quantities of barium sulphate without significant increase in viscosity and specific gravities close to 3 are obtainable which has never before been possible with liquid suspensions A previously unknown radiographic density of the contrast agent is thus possible and the suspension stability is retained in spite of the high degree of concentration

The combination of low viscosity with high roentgenographic density and good stability will enable good rendering to be obtained An introductory material comprising over five hundred cases confirmed that the contrast medium produced excellent rendering of the mucosa Possible explanations were the good contact of the medium with the mucosa due to the miscibility of the liquid phases a certain astringency and the thin coating obtained Some results are presented in Figs 4 5 and 6 The same preparation although in a different concentration may be used for the colon as well as for the esophagus (Figs 7 8 and 9)

The suspension stability is illustrated in a simple manner in Fig 10 which depicts contrast medium that has been left standing untouched Three different preparations are compared with the new composition, the small separation of water after two hours is insignificant Fig 11 is of a similar experiment but one in which the medium has been left for 24 hours, although a slight amount of liquid lies on the surface the homogeneity in the well exposed roentgenogram is evident It should be noted that a complete suspension stability is

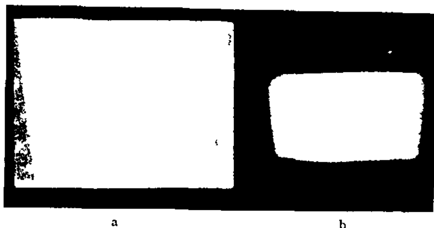


Fig 11 At 24 hours a thin layer of liquid has appeared on the surface but the homogeneity is not otherwise disturbed The roentgenogram in (b) is well exposed

actually not desirable, it would probably reduce the coating of the mucosa, which is in fact a form of sedimentation

Other substances may be added to the preparation without much changing the stability or viscosity The addition of nutrients, in the form of carbohydrates, fat and albumins, to produce the so called physiologic contrast medium for studying the transit rate through the intestine has been described by e g MATTSSON et coll (1960)

For practical purposes, the specific gravity of these contrast agents will differ from customary values, and higher values may become frequent A previously developed measurement instrument (MATTSSON 1953) has therefore been modified and will be described in a separate paper

Reproducible conditions in contrast media are essential The use of vegetal drugs always introduces the danger, for biologic reasons, of batch variations, and changes through the action of microorganisms can never be completely eliminated Contrast media composed along the lines described would seem to be more consistent, however

SUMMARY

The authors describe the development of stable barium sulphate suspensions of a lower viscosity than has so far been available It is possible with these liquid suspensions to obtain high values of roentgen ray absorption

ZUSAMMENFASSUNG

Stabile Bariumsulphat Suspensionen mit niedrigerer Viskositat als es bis jetzt moglich war konnen hergestellt werden Mit diesen flussigen Suspensionen konnen hohe Werte der Rontgenstrahlenabsorption erreicht werden

RÉSUMÉ

Les auteurs décrivent l élaboration de suspensions stables de sulfate de baryum de viscosité moindre qu on ne le croyait possible On obtient ainsi une forte absorption des rayons roentgen avec des suspensions liquides

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FROM THE RADIOLOGIC CLINIC (DIRECTOR: PROF. J. HOLÝ) OF THE FACULTY OF MEDICINE, J. E. PURKYNĚ'S UNIVERSITY OF BRNO, CZECHOSLOVAKIA

IDIOPATHIC SCOLIOSIS CAUSED BY A SHORT SPINAL CORD

by

M. ROTH

The causative mechanism of scoliosis has remained obscure so that about 90 per cent of cases must still be regarded as idiopathic (COBB 1948). Idiopathic scoliosis has characteristic features: its onset and progression is confined to the growth period of life and most affects the lower half of the thoracic spine. The primary scoliotic curvature is followed, of course, by compensatory scoliosis in the neighbouring parts of the spine. The attention of investigators has been focused mostly on the vertebrae and to some degree on the muscles and ligaments, whereas the nervous system has been almost completely neglected. An explanation of the pathogenesis of idiopathic scoliosis based on the synthesis of neuroradiologic observations and of the morphologic features of the scoliotic vertebrae will be offered in this communication.

Conventional a.p. roentgenograms of an ordinary thoracic idiopathic scoliosis reveal more or less conspicuous thinning and reduced height of the concave-sided pedicles. This by some observers may simply be ascribed to a distortion in projection, but oblique positioning of the patient will reveal the true condition (Figs. 1, 2 and 3). In severe scoliosis the concave-sided pedicles may even

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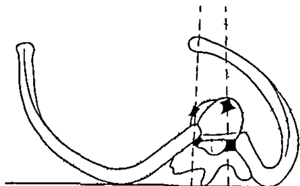


Fig 1 Correction of distortion in projection in scoliosis by oblique positioning of the patient



Fig 2 Thoracic idiopathic scoliosis Slight scoliosis with only minimal wedging of the vertebral bodies

Fig 2

be reduced to thin bony lamellae (Fig 3, b and c) In secondary lumbar scoliosis accompanying a primary thoracic curvature on the other hand, a roentgenogram will show flattening of the medial aspects of the convex sided pedicles and a slight *increase in their height* (Fig 4) *The flattening of the pedicles* in scoliosis may neuroradiologically give the impression of pressure atrophy associated with intraspinal expansive processes and the sclerotic reaction of the involved pedicles (Figs 2 and 3) may suggest a long pressure effect

The painstaking studies performed mostly during the last decades of the past century by LORENZ (1886), ALBERT (1890), NICOLADONI (1894) and SCHULTHESS (1905–1907) correlate the roentgenologic findings with the morphologic features of the scoliotic vertebrae A constant feature of a scoliotic thoracic vertebra is thinning of the concave sided pedicle (Fig 5) which may be reduced even to a paper thin bony plate The vertebral foramen of a scoliotic thoracic vertebra *is deformed and ovoid in shape, with the broader extremity directed* towards the convexity of the scoliotic curvature The narrower concave sided extremity of the deformed foramen represents in severe scoliosis a recess arched over by the thinned pedicle which at the same time is bent craniad and outwards



F g 3



Fig 3b



F g 3c

Fig 3 Tl orac c id opathic s olios more marked than in f g ? Sp e projected obliquely w th a iew to demon trate tl e ertebrae more or less sagittally a) Tomogram b) and c) Mo e se ere scol osis with reactive sclerosis of the pedicles the ped cles on the concave a pect ap pear ed d to m re bony lam llae and are dim ni hed in iz



F g 4 S conda y luml ar curve accompan ing a primary tl ra curv Tl conve ded ped les ap ar fl t n l a d in re ed in heigl t

F g 4

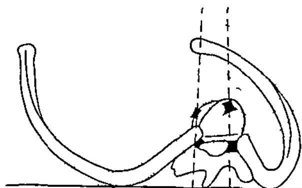


Fig. 1. Correction of distortion in projection in scoliosis by oblique positioning of the patient.



Fig. 2. Thoracic idiopathic scoliosis. Slight scoliosis *with only minimal wedging of the vertebral bodies.*

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be reduced to thin bony lamellae (Fig. 3, b and c). In secondary lumbar scoliosis accompanying a primary thoracic curvature, on the other hand, a roentgenogram will show flattening of the medial aspects of the convex sided pedicles and a slight increase in their height (Fig. 4). The flattening of the pedicles in scoliosis may neuroradiologically give the impression of pressure atrophy associated with intraspinal expansive processes, and the sclerotic reaction of the involved pedicles (Figs. 2 and 3) may suggest a long pressure effect.

The painstaking studies performed mostly during the last decades of the past century by LORENZ (1886), ALBERT (1890), NICOLADONI (1894) and SCHULTHESS (1905–1907) correlate the roentgenologic findings with the morphologic features of the scoliotic vertebrae. A constant feature of a scoliotic thoracic vertebra is thinning of the concave sided pedicle (Fig. 5) which may be reduced *even to a paper thin bony plate. The vertebral foramen of a scoliotic* thoracic vertebra is deformed and ovoid in shape with the broader extremity directed towards the convexity of the scoliotic curvature. The narrower concave sided extremity of the deformed foramen represents in severe scoliosis a recess arched over by the thinned pedicle which at the same time is bent craniad and outwards

(Fig 5a) Minimal thoracic scoliosis (Fig 5c) produces slight thinning of the concave sided pedicle this suggests that the initial bony changes in idiopathic scoliosis occur in such pedicles

NICOLADONI and SCHULTHESS always found the convex sided pedicle thinned in lumbar scoliosis associated with primary thoracic scoliosis (Fig 6) They considered this finding to be a characteristic feature of lumbar scoliosis in contradistinction to thoracic scoliosis The involved lumbar pedicle is thinned by flattening of its medial aspect whereas its height is unchanged or perhaps increased (Fig 6b) ALBERT stated it seems that the pedicles of a lumbar scoliotic vertebra dispose of the same quantity of bone material but its distribution is different

At the earliest stages of embryonal development the spinal cord occupies the entire length of the spinal canal and each spinal nerve takes its course horizontally and centrally through its circular intervertebral foramen (Fig 7a) During the ascent which starts in the fourth embryonal month as a result of physiologic growth disproportion between the rapidly elongating vertebral column and the slower growing spinal cord the nerves assume a craniad eccentric position in the foramina owing to traction of the ascending cord (TONDURY 1958) so that the medio-caudal aspect of each pedicle is moulded by and reflects the course of the respective spinal nerve (Fig 7b) A state of mild longitudinal tension will be produced by the ascent and maintained in the intraspinal neural structures (O CONNELL 1946) during the whole growth period of life The traction effect of the spinal nerves is of decisive influence upon the position of the spinal cord within the spinal canal as well as upon the shaping of the intervertebral foramina (ROTH 1965 1966)

The tension of the spinal nerve roots under normal conditions is distributed symmetrically on both sides of the midline and the straight course of the spine is thus maintained If however at any moment during the growth period the cord begins to lag too much behind the vertebral column the neutral tension will be abnormally increased Let us suppose at first that this increase in tension is asymmetrical i e unilaterally higher Correction of the disturbed tension equilibrium is then achieved by lateroflexion of the spine towards the side of increased tension (Fig 8a) With lateroflexion shortening of the concave sided zone of the vertebral column takes place the unilateral increase in nerve tension is relieved and the tension equilibrium restored

This purposeful lateroflexion is at first functional and accomplished at the expense of elastic deformation of the soft parts Soon of course after the maximal movement of the intervertebral joints and compressibility of the disks has been surpassed structural changes of the vertebral bodies will appear these consist mainly in wedging by which further shortening of the concave sided zone of



Fig 5 Vertebrae seen from above side of convexity indicated by the curved lines a) From marked left convex thoracic scoliosis Thinning and altered direction of the concave sided pedicle ovoid vertebral foramen with a concave sided recess b) Right convex thoracic scoliosis The concave sided recess of the foramen is broader than in (a) c) Minimal right convex thoracic scoliosis Thinning of the concave sided pedicle and deformation of the foramen From LORENZ (1886)

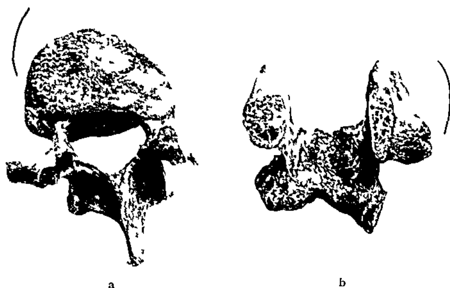


Fig 6 Vertebrae from a severe left convex secondary lumbar curve a) The L 2 vertebra shows thinning of the convex sided pedicle b) Frontal section through the pedicles of L 3 seen from in front Flattening and increase in height of the convex sided pedicle From NICOLADONI (1894)

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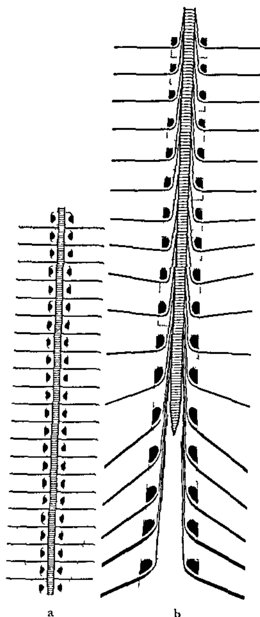


Fig 7 a) At the early embryonal period the *spinal cord occupies the entire length* of the spinal canal Each spinal nerve runs horizontally and centrally through its circular shaped intervertebral foramen b) During ascent of the cord the nerves assume a craniad eccentric position in the foramina The medio caudal aspect of the pedicles reflects the course of the respective spinal nerve

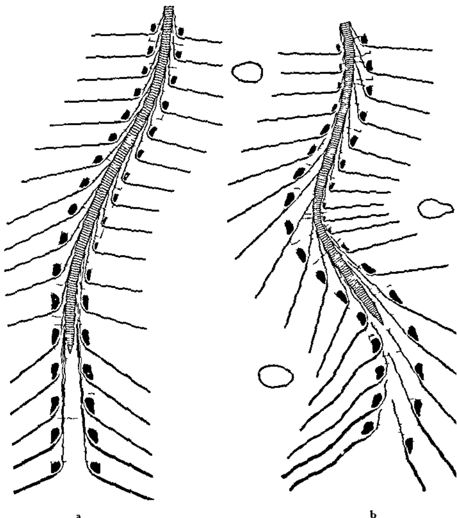


Fig 8 a Abnormal increa e in neural ten ion unilate ally higher (ind cated in the sc by the shorter 6th to 11th left sp nal nerves) The disturbed nerve tens on symmetry has e tored by lateroflexion of the sp n towards the side of higher tension pressure atrop tl on a id d ped cles b) Severe progressi e lower thoracic structural scoliosis with t ning and wedgi g of the ve teb al bod es further sl ortening of the vertebral column s s e tl in ing of the conca e s ded ped cles due to pres ure effect from the spinal and ord Compen atory uppe thora ic and lumbar curves the convex sided lumbar a tr t hed with resulting flatten ng of the pedicles The characteristic deformat on ross sect on of the sp nal canal in th upper thoracic lower thoracic and lumbar reg d cated at the corre pond ng levels



Fig 9 Roentgenograms of models of thoracic vertebrae cut from foam plastic material and soaked in barium a) Normal conditions b) Typical scoliotic deformation of the foramen and thinning of the left sided pedicle produced by the pull of the spinal nerve The convex directed rotation (i e to the right) of the vertebral body seen in this elastic model represents changes which in the living subject take months and years

the vertebral column is achieved A progressive structural scoliosis develops (Fig 8b)

The abnormal increase in neural tension is concentrated and reflected at the intervertebral foramina where the concave sided pedicles undergo pressure atrophy along their medio caudal aspect corresponding to the course of the taut nerves The concave sided recess of the vertebral foramen (Fig 5a) represents the pressure imprint of the spinal nerve on the pedicle In more severe scoliosis, the spinal cord itself, displaced by the pull of the nerves to the concave sided wall of the spinal canal, also contributes to the ovoid shaped transformation of the foramen (Figs 5b and 8b) The prolonged pull and pressure of the taut nerve on the pedicle is the reason why the concave sided neuro central junction is completely open at an age when the convex sided one is already closed (Fig 10) Growth is thus prolonged on the concave side, causing an elongation of the pedicle, which in turn produces convex rotation of the vertebral body (NICOLADONI 1894 KNUTSSON 1963) (Fig 9)

Flattening of the convex sided pedicles in compensatory lumbar scoliosis results from passive stretching of the convex sided nerves (Fig 8b) The pressure imprint of the ventrally running lumbar spinal nerve may be clearly seen in the roentgenogram of a scoliotic lumbar vertebra (Fig 11)

The clinical course of idiopathic scoliosis thus depends on the degree of growth retardation of the intraspinal nervous structures in respect to the vertebral column The greater the difference between the two growth rates, the more severe the resulting scoliosis After the growth in length of the vertebral column has



Fig 10 Vertebra Th 10 from a right-convex scoliosis in a child The concave sided neurocentral junction is open the convex sided one is fused thinning and sclerosis of the concave sided pedicle with ovoid deformation of the vertebral foramen caused by the pull of the spinal nerve (cf fig 9) From NICOLADONI (1894)



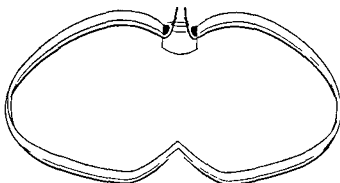
Fig 11 Roentgenogram of vertebra L 5 from a right-convex compensatory lumbar scoliosis (viewed from below) The convex sided pedicle is thinner its medial aspect bears a pressure imprint from the spinal nerve From SCHULTHESS (1905—1907)

ended the scoliosis does not progress any more since the abnormal neural tension ceases to work and there will consequently be no reason for further detensive lateroflexion of the spine

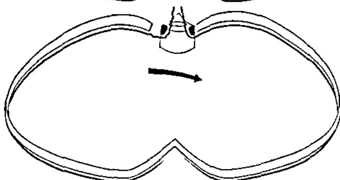
The concave sided nerves are in the course of idiopathic scoliosis more stretched and consequently more involved than their convex sided counterparts which explains the apparently paradoxical electromyographic phenomenon in scoliosis viz the higher electrical activity in the muscles on the convex side of the curve (e g ALLENBACH & WIEST 19ɔ3 ZUK 1962)

Discussion

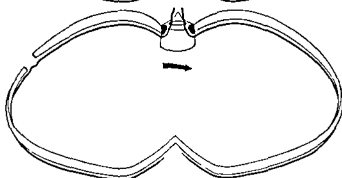
It might be argued that the abnormal tension with pressure erosion of the pedicles are mere secondary effects brought about by a passive stretching of the nerves in scoliotic deformity caused by some obscure mechanism The vertebro-



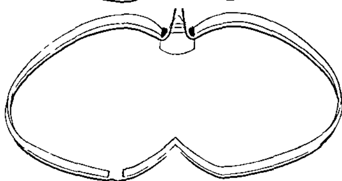
a) Normal arrangement of a rib ring The slight tension of the spinal nerves produced by the ascent of the cord and the inspiratory expansion of the chest wall is normally bilaterally symmetrical and the straight course of the spine is maintained



b) Resection of the dorsal part of the rib results in a slight collapse of the thoracic wall and slackening of the respective spinal nerve disturbed neural tension symmetry is restored by latero flexion of the spine towards the other side



c) Resection of the rib more laterally is accompanied by only slight slackening of the para foraminal portion of the nerve so that less scoliosis results



d) Resection of a ventral part of the rib has practically no effect upon nerve tension and is therefore not followed by scoliosis

Fig 12 a –d

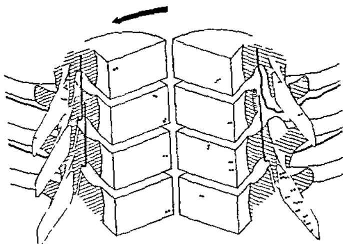


Fig 13 Schematic view from behind of a vertebral column segment cut in the median plane and opened By unroofing the intervertebral foramen by hemilaminectomy the respective spinal nerve loses it support and therefore slackens Nerve tension equilibrium restored by lateroflexion of the spine towards the other side

neural growth theory is however strongly supported by certain experimental and clinical observations

With simple lateroflexion of a primarily normal thoracic spine a passive stretching of the convex sided nerves takes place so that pressure atrophy of the convex sided pedicles may be expected In thoracic idiopathic scoliosis the opposite is true however

LANGENSKIOLD & MICHELSSON (1961) and MICHELSSON (1965) came to the conclusion that the operations most effectively inducing severe progressive structural scoliosis in growing rabbits and pigs were unilateral resection of the dorsal ends of the 6th to 10th rib and radical *hemilaminectomy* The primary at first functional curve was invariably convex towards the side of operation and more or less severe permanent structural scoliosis developed during the subsequent weeks and months The farther lateral to the rib tubercle the resection was performed *the less was the resulting scoliosis*

These findings are readily explained by changes in the tension equilibrium of the spinal nerves (Fig 12) Resection of the dorsal parts of ribs results in slight collapse of the chest wall accompanied by slackening of the respective spinal nerves The resulting tension imbalance is corrected by a reflex lateroflexion towards the non-operated side (Fig 12b) The farther lateral the resection the



Fig 14 Post thoracoplasty scoliosis with convexity directed typically towards the operated side Ascent and growth plasticity of bones are long over in the adult and therefore no appreciable alteration of pedicles Neural tension asymmetry will be accentuated during inspiratory expansion of the thoracic wall

less will the paraforaminal portion of the nerves slacken, the resulting scoliosis will be less severe (Fig 12c)

Resection of the ventral part of the rib has no effect upon nerve tension and is therefore not followed by scoliosis (Fig 12d) Radical hemilaminectomy has an analogous effect on the neural tension balance (Fig 13)

The post thoracoplasty scoliosis, first described by BISGARD (1934) is essentially of the same nature as that produced experimentally by LANGENSKIOLD and MICHELSSON In an adult, of course, no thinning of the pedicles takes place since ascent of the cord and growth plasticity of the skeleton are then long over (Fig 14)

It is generally taken for granted that in lateroflexion of the spine the cord runs the shortest way in the spinal canal viz along the concave sided wall of the curvature This presumption seems to be proved by the fact that in idiopathic scoliosis the cord is invariably found to be lodged in the narrow concave sided recess of the spinal canal, and the nerve roots are unusually taut (JAROSCHY 1928, MCKENZIE & DEWAR 1949, MOVSOVIC 1964) (Fig 15)

Shortening of the trunk is a characteristic feature of scoliotic subjects If,





Fig 15 a) The dural sac in severe scoliosis as exposed by laminectomy The dural sac and the spinal cord are lodged in the concavity of the spinal canal the visible nerve roots are taut Courtesy of McKENZIE & DEWAR (1949) b) Cross-section of the spine in right convex idiopathic thoracic scoliosis (viewed from above) The spinal cord is in intimate contact with the thinned concave sided pedicle Courtesy of MOVSOVIC (1964)

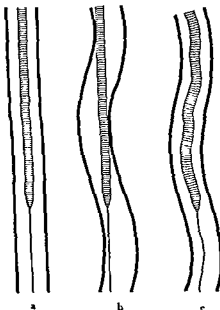


Fig 16 a) Normal arrangement of the cord within the straight growing spine b) Growth in length insufficiency of the cord forcing the axial skeleton into *curvatures* The cord runs the shortest way within the spinal canal c) If the cause of idiopathic scoliosis were some affection of the axial skeleton not related to the intraspinal nervous structures the normal cord and nerves would rest slackened within the shortened scoliotic spinal canal

therefore, the cause of idiopathic scoliosis were some affection of the axial skeleton not related to the intraspinal neural structures, the normal cord and nerves would necessarily be expected to slacken in the shortened scoliotic spinal canal (Fig. 16c). The actual behaviour of the cord and nerves in scoliosis (Fig. 16b) would however seem to suggest a primary growth insufficiency of the cord or the nerves, or of both, which would account for the curvatures of the spine. In other words, the spine cannot grow straight but is forced into curvatures.

The proposed interpretation readily explains the negligible role played by gravity and strain in the production of scoliosis as well as the rapid deterioration of scoliotic curvatures in the periods of accelerated body growth.

SUMMARY

An explanation of the pathogenesis of idiopathic scoliosis based on the disturbance of the relative vertebro-neural growth is presented. This concept is supported by neuroradiologic, experimental and clinical observations.

ZUSAMMENFASSUNG

Die Pathogenese der idiopathischen Skoliose wird auf eine Störung des relativen Wachstums der Wirbelsäule und des Nervensystems zurückgeführt. Diese Erklärung wurde auf Grund neuroradiologischer, experimenteller und klinischer Beobachtungen gegeben.

RÉSUMÉ

L'auteur présente une explication de la pathogénie de la scoliose idiopathique basée sur la perturbation de la croissance relative de la colonne vertébrale et de la moelle. Cette conception est appuyée par des observations neuroradiologiques, expérimentales et cliniques.

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FROM THE SENSITOMETRIC DEPARTMENT, AB GEAVERKEN, STRANGNAS, SWEDEN

RADIATION DAMAGE TO ROENTGEN FILMS

by

Arne Lundh

The photographic characteristics of stored roentgen films change The most easily detected changes from a diagnostic point of view consist of decrease in *contrast and increase in fog, the sensitivity (speed) usually remains fairly* constant As fresh films render better radiographic quality than old films, the manufacturers give an expiry date on each box before which time the material should be used *This guarantee is valid only on condition that the films have* been stored in a cool and dry place and protected from radiation

Humidity and noxious fumes do not normally cause defects in unopened boxes as these contain an *inner, sealed wrapping* which is comparatively moisture proof, when this has been broken the contents are apt to be affected by fumes (chemical damage) from without and must be used as soon as possible

The photographic characteristics may also be influenced if films are stored at unduly high temperatures, the storage temperature is however usually not of much importance in the production of fog as long as it remains below 20° C The demands on the temperature of the storage space are therefore not high but the temperature should not exceed 20°C for any length of time

The main cause of normal fog increase during storage of roentgen film lies

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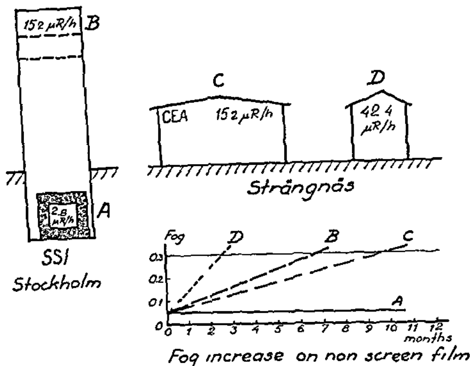


Fig. 1. Samples of film were stored in four premises where the radiation level had been measured.
A — Radiation protected room with hoforsite walls in the basement of the Swedish National Institute of Radiation Protection (Statens Strålskyddsinstitut (SSI)), Stockholm.
B — Seminary room at the top of the same building. Brick walls.
C — Reference storing room at the Cea factory, Strangnas. Brick house.
D — Villa in Strangnas built of aerated concrete containing uraniferous alum shale.
The diagram shows the fog increase in a high sensitive non screen roentgen film stored in the four premises.

in its high radiation sensitivity. No rooms are completely free from radiation and the emulsion is always subjected to continuous exposure from the surroundings. The influence of the natural radiation (background radiation), additional radiation during storage and handling of the films in roentgen departments as well as defects caused by light will be discussed in this communication.

Characteristics of fog. Diffuse irradiation of a roentgen film produces an evenly distributed density or fog. Fog may also be caused by a chemical effect on the silver bromide grains in the coating so that the grains become spontaneously capable of being developed without exposure. Through a combination of such

factors, fog always increases with storage time The actual degree of fogging is also dependent on the composition of the developer and the degree of development The more the film is developed, the more grows the fog, and how much the amount of fog increases will depend on the characteristics of the coating and the composition of the developer Every control of the fog levels at various storage times must therefore be made under constant processing conditions

Evenly distributed fog means that the density scale available for diagnostic information decreases The film requires more light for examination, e g at a fog of 0 3 (= log 2) twice as much light is required for it to appear equally bright as a film that is fog-free

A film with a fog of about 0 05 is usually considered free from fog and fog values of 0 15 to 0 20 are tolerated without more ado A value of 0 3, absorbing one half of the examination light, may be taken as the limit for permissible fogging (All fog values are measured above the constant base density, optically representing only a coloured plastic filter, combined with the photographic coatings) Moreover, a mottled or unevenly distributed fog means distinct interference in the information content of the image and may contribute to a misleading diagnosis Irregular fogging or superfluous detail in the film by false radiation are therefore considerably more dangerous than evenly distributed fog

When films are damaged by light their practical speed increases and the gradation softens Penetrating radiation (roentgen and gamma radiation) does *not lead to the same degradation of the film It causes only fog and has no ap*preciable influence on the sensitivity

Different causes of radiation damage to films

Storage defects (1) radiation damage from building materials If roentgen films are stored at a constant temperature of about 20° C (68° F) fogging will practically always stand in a linear relationship to the storage period The density at low values of controlled roentgen exposures also increases in direct proportion to the dose of radiation which is not the case with exposure to *light* This behaviour of the film leads to the suggestion that increase in fog is mainly de*pendent upon exposure of the film boxes to penetrating* radiation from the surroundings (The radiation caused by different building materials has already been exhaustively investigated by HULTQVIST 1956 who established considerable variations)

An investigation check in premises with different radiation levels confirmed this assumption (see Fig 1) The investigation required comparative storage of films at an unusually low level of background radiation and a special chamber was made available at the Swedish *National Institute of Radiation Protection*

(Statens Stralskyddsinstitut, here called SSI) A radiation protected room A shielded with a mineral from Hofors in Sweden of unusually low activity is situated in the basement (HULTQUIST 1956 LINDELL & REIZENSTEIN (1963) for simplicity it will be called the hoforsite room The natural radiation level in room A is as low as 2 8 μR/h and the temperature about 20 C above ground level the house is built of brick

For the control a set of films of four different types with various sensitivities to roentgen rays were placed in the hoforsite room A and another set in a seminary room B at the top of the same building where the radiation level measured 15 2 μR/h Packages from the same film batches were also stored in the brick reference store C at AB Ceaverken Strangnas in which the radiation level was the same as at the SSI, or 15 2 μR/h Finally, samples of the same film batches were placed in a building D of blue aerated concrete containing alum shale which has a considerably higher radiation level in this case 42 4 μR/h The alum shale contains uranium and is a fundamental component of this type of aerated concrete being manufactured under two different designations in Sweden (Blue aerated concretes manufactured in other countries under the same designations must not contain alum shale and are consequently less radiating No general conclusions regarding aerated concretes or other building materials may therefore be drawn from the above observations but the material will have to be checked in each instance See references to the literature)

The checking comprised three months of storage during which time the packages were exposed to about 6 mR in the hoforsite room A 34 mR in the brick houses B and C and 94 mR in the aerated concrete house D These doses do not seem to be especially high and anyone staying day and night for a year in the concrete house D would not receive more than about a tenth of the dose allowed for those in radiologic work From a photographic point of view, however the radiation must not be neglected

MATTSSON (1955) measured the density curves as a function of the radiation dose at different voltages He established that a film equivalent to our Test X/H film gave a density of 1 0 after an exposure to only 50 mR at 180 kV In fact the radiation from building materials is considerably more energetic and is less easily absorbed by the film It is therefore quite reasonable to assume that appreciably lower density values are achieved than at 180 kV, especially as the exposure is slow and fading of the latent image must be taken into consideration The figures by themselves indicate plainly that radiation from building materials is of such a magnitude that clearly observable fog must appear in the film

For an extra checking to verify that the increase in fog was being caused by penetrating radiation further films were placed in the same rooms these films

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concrete house D, and the rapid fog increase corresponded well to the higher radiation level.

Three of the films checked are incorporated in the tabulated data given below, the shelf life being extrapolated into months at the fog value of 0.3 when stored in the four different room.

Premises	Shelf life in months		
	Test X/H	*Singul X/Roll*	*Wicor X*
A SSI hoforsite room	>48	48	36
Plus lead foils	24	—	—
B SSI brick room	7	9	16
Plus lead foils	3.5	—	—
C Ceaverken brick room	11	13	24
D Aerated alum shale concrete building	2.5	4	5

Since no measurable increase in fog had been noted during the three months of storage in the hoforsite room an extrapolation can of course give no reliable shelf life value. The figures 48 and 36 months are therefore the lower values for shelf life.

It is remarkable on the other hand how strongly shelf life was influenced by the building materials in the other storage rooms. Test X/H is of course most easily fogged as it has the highest radiation sensitivity of the non screen types of industrial films and also has the highest content of silver. The ordinary film Wicor X for use in cassettes with fluorescent screens is as expected the most stable in that respect since the sensitivity to blue light is the dominating factor and the silver content is as low as possible considering the rapid processing in developing units. Singul X/Roll is a non s reen film for development in such units and the silver content and therefore its sensitivity to radiation has been lowered in relation to Test X H in order to achieve the desired characteristics. It consequently takes an indermediate position between Test X/H and Wicor X with regard to fogging from background radiation.

The test with lead foils gave a satisfactory confirmation that the increase in fog is caused by ionizing radiation (Fig. 3). In the hoforsite room A the increase in fog under the lead foils was slight and may have been due partly to the intensification by the foils and partly to a weak activity in the lead (uranium). In the seminary room B with the background radiation 15.2 μR/h the fog increased twice as rapidly under the lead foils as in the bare film which gives an intensification factor of approximately 2. The lead foils intensify by converting

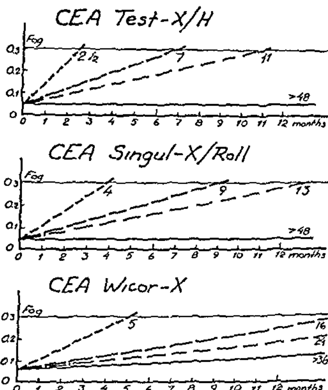


Fig 2 The shelf life of a film stated in months until the fog has risen to 0 3 Good correlation could be established between shelf life radiation sensitivity of the film type and the radiation level of the storing place Test X/H has the highest silver content and radiation sensitivity Wicor X the lowest Singul X/Roll has an intermediate position The curves indicate the storage premises as follows Hoforsite room A at SSI — Brick room B at SSI — — — Brick room C at CEA — — — Aerated concrete villa D - - - - - (See also (fig 1)

being packed with the emulsion layers in contact with thin lead foils (0 02 mm) of the type used as intensifying lead screens for industrial films

The result of the examination was striking, as is evident from Fig 2 The storage time of three months in the hoforsite room A caused no measurable increase in fog in the non screen films, two of which (CEA Test X/H and Singul X/Roll) are now considered, whereas the ordinary film for use with fluorescent screens, in this case CEA Wicor X, underwent a slight increase, corresponding to more than 3 years storage to a fog level of 0 3 The increase in fog was measurable but not quite equal in the seminary room B of the SSI, and in the control store C at AB Ceaverken, in both of which the radiation level according to measurements was the same The increase in fog was more rapid at the SSI The differing spectral composition of the radiation in the two places must be the explanation it is more photographically effective, i e it is more easily absorbed by silver bromide at the SSI

If the shelf life of the film is determined by the number of months elapsing before the fog has reached 0 3 (at a normal development of 5 minutes at 20° C), the shelf life will be considerably shortened in premises B and C relative to the film in the hoforsite room A This fact was still more obvious in the aerated

roentgen films (non screen type), surrounded by samples of the materials for at least three months The film envelopes should be inserted into heat sealed humidity proof envelopes e g an aluminium coated plastic All samples must be stored at normal room temperature on the same premises where the background radiation level must not be abnormally high The sample giving the lowest increase in fog in the film represents the best building material for photographic stock rooms Even cement and sand for the concrete must be controlled and the best materials selected

As increase in fog in a faultless film is mainly dependent upon exposure from surrounding building materials or from the ground the expiry date stamped by the manufacturer on the film boxes has a limited value It does not specify the actual shelf life at the place where the films are being stored A cautious manufacturer chooses a shorter period of guarantee in order to force the customer to use the films as soon as possible Ordinarily it is stated on the boxes that they are to be stored in a cool dry place It is however more important that the films are stored at a reasonable radiation level e g 10 to 15 μR/h at this level the monthly fog increase for a high speed non screen film is in the order av 0 02 to 0 03 As the fog increase is directly proportional to the radiation sensitivity this precaution is less important with low speed industrial films There is every reason to believe that all other types of photographic silver halide materials are damaged in the same manner in so far as they are highly sensitive to penetrating radiation That cold storage is favourable to colour sensitized materials and colour films is well recognized

Storage defects (2) damage caused by inadequate radiation protection It is now evident that even though weak the radiation from building materials and the ground is the most important source of storage fog in roentgen film A department working with roentgen tubes for diagnosis and therapy requires exceedingly effective shielding in order to reduce the influence of all undesired radiation added to the background radiation In the previously mentioned instance (alum shale aerated concrete) it was indicated that an increase of two to three times the background radiation causes a corresponding shortening of the effective life of all roentgen films through an increase in the fog level Even if the shieldings of cobalt guns or suchlike are considered completely satisfactory for the operating team it is inevitable that any films in the region will become rapidly fogged It is therefore best to arrange for the main storage space for films and roentgen equipment to be well separated and avoid prolonged storage of single boxes in the roentgen departments themselves

Less known perhaps is the fact that valve tubes in certain circumstances may act as roentgen tubes and cause damage to films The tubes in departments for therapy

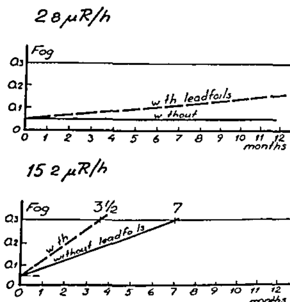


Fig. 3. Lead foils of 0.02 mm influence the increase in fog by electron intensification. Film: Cea Test X/H.

the high energetic γ radiation into electron radiation which is more effectively absorbed by the silver bromide. It is a known fact that lead foil packed films undergo more rapid ageing than the same films in folder wrappings. This is usually not a chemical damage but an exposure effect due to the intensifying effect of the lead foils.

That the fog in each case presents a coarse structure is easily explained. An appreciable quantum mottle is produced by the high energetic quanta from the dominating radium radiation. A light fog or chemical fog has a smooth structure.

The conclusion to be drawn from the observations stated above is therefore that the increase in fog in relation to storing time is practically exclusively caused by exposure to radiation from building materials added to background radiation from the earth etc. This is true on the assumption that the films are not stored at abnormally high temperatures and that no technical defects in manufacture produce a chemical increase in fog. It would probably therefore *not pay to build specially cooled stores for ordinary roentgen films, at least not* in the temperate zones of the world, the stipulation that the temperature of the storage space must not exceed a normal room temperature of 20° C other than temporarily should suffice.

On the other hand, it must be considered imperative to build storage premises and their surroundings of materials having a low radiation level. Directions about such materials may as a rule be obtained through the institutes for radiation protection in the respective countries as these are in a position to check different materials. *Building materials may also be checked by storing high speed industrial*



Fig 5 Radiation damage from a defective therapy valve separated from the film boxes by only a wooden wall

o casions exposures were made when the radiation protected door between the operating room and the roentgen room had not been quite closed The door to the processing room was hit by direct radiation from an apparatus and the films in the dispenser were ruined Distinctive reproductions of nails were present in all the films (Fig 6)

Damage from radioactive dust The atom bomb tests produced fall-out of radioactive dust over all the continents Paper mills use large quantities of water for washing and fouling of this water by the fall out was inevitable Long life active particles were baked into the paper pulp and when a protective wrapper with such a baked in particle had been in contact with a film for some months a circular strongly blackened fog defect occurred (Fig 7) This appeared not only on the nearest film sheet but could sometimes be repeated on every sheet in a whole box of films the black spot could be between 1 and 2 cm in diameter Spots caused by radioactive fall out are always situated at the same relative site on all the damaged film in the box and as distinguished from discharge spots always appear with a matt surface on both sides of the film (penetrating radiation) Spots produced by static are on cursory examination rather similar but are matt on only one side of the film

It is impossible to avoid isolated fall-out spots as the particles are so small that they cannot be measured The appearance of large radioactive particles became rapidly less frequent after the termination of the atom bomb tests and damage by fall-out is now relatively rare The paper mills and the film factories have taken extensive precautions to prevent radioactive dust from being introduced into materials

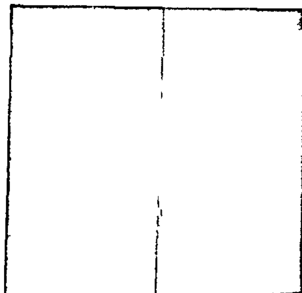


Fig 4 Two film sheets from the same box damaged during storage by radiation from a therapy valve tube in an adjacent room

are operated at very high voltages and, being able to generate highly penetrating radiation, are always to be considered dangerous from a radiation point of view Valve tubes in diagnostic apparatus are in operation during shorter periods and do not usually generate appreciable radiation But if their cathodes break down, the voltage drop increases and they start to act as roentgen tubes, and incidences of this kind are not too rare Dry rectifiers have however already to a great extent replaced valve tubes in therapy as well as in diagnostic departments and these are of course quite harmless from a radiation point of view

Not so long ago, very extensive damage was caused in a Swedish hospital where the stock of films had been placed in a room adjacent to the valves of the therapy department All the films in that stock displayed mottled fogging which by its diffuse character simulated a manufacturing defect When several sheets from the same box were developed, however, it became evident that the marks on every sheet in the box had exactly the same shape and position They were quite simply shadow figures from stones and steel reinforcement in the concrete wall as demonstrated in Fig 4 which shows two sheets from the same box The contrast in the print has been somewhat increased for reproduction in a printing block

In another case, film boxes were stored in a dark closet on the outside of the valve tube room of a diagnostic department One tube broke down and started to function as a roentgen generator, causing all the films in the closet to be extensively damaged (Fig 5)

In a third, rather odd case of many years ago the door between the processing room and the roentgen operating room was not radiation protected On some



Fig 8 Several cassettes had been brought into the roentgen room without adequate radiation protection Parts of the stand of the equipment have been reproduced

film its position being dependent upon how the cassette is placed at the time It may sometimes be exceedingly difficult to determine the cause of the damage and it will be necessary to examine all the positions passed by the loaded cassette during the work Accidental double exposures may easily occur especially when work is performed by inexperienced personnel and often during holiday periods or through faulty routine Cassettes may remain in the roentgen room unprotected before use and several cassettes may often lie together in the examination room during tomography

Fig 8 shows a chest with an apparatus stand superimposed It is always useful to study the contours of the shadows in order to identify details and enable a faulty working technique to be corrected Defective equipment or leaks in radiation fields may also cause damage A crack in a wall may permit undesired radiation to penetrate into cassette pass-boxes or conveyors for cassettes and thus damage the films Only a dark streak may appear in the film and be difficult immediately to identify as damage caused by radiation If it is remembered that damage due to penetrating radiation is always identical on both sides of the film sheet and is also always of equal sharpness it is easy to distinguish it from damage by light on the bare film

It may have been established that the damage has been caused by penetrating radiation but at the same time it may be hard to determine due to which circumstance the damage has occurred especially if the fault is isolated and difficult to reproduce Another difficulty in locating the source of damage may arise if the damage has occurred in connection with a faulty handling of the cassettes

Fig 6 Damage by irradiation of films in the storage dispenser of the darkroom A protected door to the diagnostic department had been left open

Fig 7 Damage by radiation from radioactive dust (atom bomb fall out) baked into the protective wrapping paper Exposure time 9 months

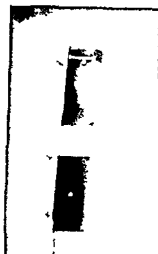


Fig 6

Fig 7

Damage during transport Fog increasing in direct proportion to length of time will appear in films placed in the vicinity of a radioactive isotope during transport Boxes containing radiation sensitive films must bear the word Foto upon a reproduction of a perforated film strip in order to avoid such damage It should indicate sensitivity to heat and penetrating radiation Boxes bearing this marking must be placed as far from cases with radioactive isotopes as possible Damage seldom occurs, though when it does it may be extensive More often shadow figures of nails or other metallic subjects may appear in the developed films, and thus enable conclusions to be drawn as to the origin of the damage

Damage by radiation during work with loaded cassettes If a loaded cassette is exposed to undesired roentgen radiation, the film will be damaged by exposure to light from the tungstate screens The film screen combination has a high sensitivity to radiation and films in cassettes are more easily damaged than the same film used without intensifying screens A dose of about 3 mR may cause a density of 1 with a normal film screen combination (MATTSSON 1955) Since both screens fluoresce the damage will be approximately equally exposed on both sides of the film sheet, the side closer to the source of radiation is sometimes a little more exposed Visible shadow details are ordinarily equally sharp on both sides which can be detected by scraping off the emulsion layers at corresponding sites The density is usually considerably higher than when the film has been damaged by direct irradiation of the film box or dispenser

The damage is seldom localized to the same relative site on several sheets of



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especially with an *uncooperative operator* It must of course be admitted that the operator may be unaware of the fact that his inappropriate working technique is the source of damage In a particular instance, an investigation of damage led to the elimination of a radiation leak, extremely dangerous to the personnel Fluoroscopy of a chest was followed by frontal and lateral exposures It appeared that the exposed frontal cassette was left on a chair while the patient was adjusted by fluoroscopy for the lateral view The radiation shielding was however defective and when the patient was in position for the lateral view, radiation produced a black streak on the film in the frontal cassette left on the chair, the operator had also during screening been exposed to the same radiation leak

As is well known, films may also be damaged by light during handling and processing The damage may arise from dark room safelights, light leaks, faulty cassettes or from white light when the dark room is being cleaned Electrostatic discharges represent potential sources of damage by light

Identification of damage by penetrating radiation and by light The density and the contour sharpness will be practically identical on both sides of the film sheet in all cases of damage by penetrating radiation in which the films are exposed without screens or between two similar screens The film surfaces may be examined either by viewing them in reflected light or by moistening them and scraping off the emulsions at two corresponding sites The side closer to the radiation source has however a slightly higher density at low energy radiation The side of the film first hit by the light is of higher density in all cases of damage by light If the light reproduces some object which is in contact with one side of the film (e g wrapping paper) the reproduction is distinct only on that side, on the other, more weakly exposed side, the detail is blurred When examining the surface gloss of the film against a light source the more damaged side is matt, whereas the other side is more glossy This procedure is employed to distinguish static spot marks from those caused by radioactive fall out

Acknowledgement

The author takes this opportunity of thanking Prof Bo Lindell and Engineer Bengt Håkansson at the Swedish National Institute of Radiation Protection for their invaluable help in the study of the influence of building materials He also expresses his gratitude to the many radiologists who have assisted with roentgenograms and investigations of the origin of damage by radiation

SUMMARY

The main causes of photographic fog and other exposure defects during storage and processing of roentgen films are described and considered in detail Particular attention is being devoted to the dominating influence of the surroundings i e the background

radiation and how the unavoidable fog increase during storage can be extensively influenced by an adequate choice of building materials The means of differentiating between damage caused by penetrating radiation and by light is discussed

ZUSAMMENFASSUNG

Die Hauptursachen der Schleierzunahme und anderer Beli htungsdefekte wahrend der Aufbewahrung und Verarbeitung von Rontgenfilmen werd n besprochen und im Einzelnen nalysiert Besonders wird der Einfluss der Hintergrundstrahlung von den umgebenden Baustoffen beachtet und auch die Frage wie die unvermeidliche Schleierzunahme beim Lagern durch die Wahl von geeigneten Baustoffen weitgehend beeinflusst werden kann Es wird erort rt wie man zwischen Schaden durch Licht und durch penetrierende Strahlung unterscheiden kann

RÉSUMÉ

l auteur décrit et etudie en detail les causes du voile au cours du stockage des films radiographiques Il etudie particulierement l influence de l environnement et le rayonnement naturel emis par les matériaux de construction L auteur examine la difference entre le voile du aux rayonnements pénetrants et celui du a la lumiere

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Book reviews

PROGRESS IN PEDIATRIC RADIOLOGY Vol I RESPIRATORY TRACT Edited by H J Kaufmann 354 pages 237 illustrations 6 tables S Karger Basel 1967 Price 68 Schw fr

The first volume in this series deals with the respiratory tract and is divided into three main sections general topics a special treatment article and specific topics

The first section on general topics opens with a chapter by Davis who discusses the *technique for radiography of children in general* The chapter contains much valuable advice especially for radiologists who have had little experience in handling infants and young children However the suggestions given *for the immobilization of youngsters* are not entirely convincing and the method recommended for quieting an infant with a dummy held in position with a large strip of adhesive tape across the face is to say the least curious Hodson s chapter on the localization of pulmonary lesions solely from a frontal view is both logical and elegant but the suggestion to confine an examination of the lungs to this view *alone cannot be said to encourage good roentgendiagnostic practice* One of the chapters in this section is devoted to bronchography a procedure less commonly employed in children than in adults It is necessary to use general anaesthesia and the results depend largely on how this is produced The method described in detail by Brunner has been found by the reviewer to give excellent results the lungs are well ventilated and *the examination can be carried out without undue haste* There are only a few *illustrations* in this chapter but they are of good quality The same cannot unfortunately be said of those to be found in the chapter by French authors on pulmonary angiography in children Neither text nor illustrations are of the standard required in modern diagnostic roentgenography

The respiratory distress syndrome presented by F B Singleton forms *the subject of the* second section In addition to this entity in its more restricted sense in other words hyaline membrane disease the author also includes several other respiratory disturbances in newborns in particular the aspiration syndrome The chapter is an excellent synthesis of clinical and roentgenologic observations and contains many good illustrations the fine reticulogranular densities appearing in hyaline membrane disease do not reproduce well however The value of the chapter is enhanced by the inclusion of comments by other investigators *who have studied these problems*

In the third section on specific topics individual or groups of authors deal with various diseases injuries or malformations the subjects are generally treated in considerable detail and the micropathologic features underlying the roentgenographic anatomy are often described as well Rare diseases such as listeriosis are also included and in the reviewer s *opinion this is fully justified in a reference* work *of this type* There are a few repetitions but these are not disturbing they are sometimes even valuable for instance when several investigators discuss the problems from different viewpoints Pulmonary lesions after inhalation of kerosene and similar substances are described among others both by *Neuhauser* and Griscom in the excellent section on aspiration pneumonia and by Baker & Grossman *in their chapter on physical* and *chemical* damage of the lung

It is most satisfactory to have found a good survey assembled in one work of the many aspects of this difficult and diversified field The illustrations also heighten its worth and each chapter contains a considerable number of references to other works *As already* pointed out however readers should not accept all the recommendations without some reserve

Kristina Ekengren

GRENZEN DES NORMALEN UND ANFANGE DES PATHOLOGISCHEN IM RONTENBILD DES SKELETS Von A Kohler und E A Zimmer 640 Seiten und 1889 Abbildungen Georg Thieme Verlag Stuttgart 1967 Preis 134 DM

This well known work now appears in its eleventh edition being eleven years since the last German edition was produced Schematic surveys of skeletal affections and systemic disorders of bone have been added These sections will certainly be most useful as a practical guide for reviewing essential findings in various bone diseases they are abundantly illustrated by well conceived and instructive drawings The bibliography represents more than 6 000 references the literature being covered up to the early sixties

Ulf Rudhe

ROENTGEN DIAGNOSIS OF DISEASES OF BONE By J Edeiken and Ph J Hodes 701 pages 785 illustrations and some tables including one of the development of the human skeleton according to Paul C Hodges 1933 Williams & Wilkins Co Baltimore 1967 Price 32 dollars

This book is reprinted from Golden s Diagnostic Roentgenology in which it forms Chapter VI of the revised pages of 1967 The principal feature is the inclusion of a great number of roentgenograms The text is developed for the teaching of mechanisms concepts and principles applicable to the large field of bone diseases

The conventional classification of bone lesions found in the textbooks of the acknowledged authorities is used as the basis for the various chapters The difficulties in separating different entities histologically are also presented and different opinions on the character of the lesions are discussed Of course examples of these difficulties are most obvious in the chapter Giant Cell Tumors The authors employ Jaffe s division of these tumours into three stages based upon the appearances of the atypism of the stromal cells — and not upon the giant cell as might have been expected from the name of the lesion Further they write Finally the grading of a tumour may be completely misleading in the individual patient since the author has seen several cases in which the histologic classification was undoubtedly grade I even though the biopsy has been obtained from a metastatic pulmonary lesion As long as dysfibroplasia fibrosarcoma or any other lesion in spongious bone with giant phagocytes is classified as a separate pathologic entity due to the presence of the giant cells this particular confusion will remain

The authors also classify myelomas and Ewing s tumours as bone tumours despite the fact that these do not originate from mesenchyma of osteogenic capacity

Most of the illustrations are instructive for comparison of findings in routine work Some of them could perhaps have been cut to demonstrate more distinctly the features of the lesion. It appears inconsistent to the reviewer that hands and feet are inverted 180 in relation to the rest of the skeleton — as is usually the case This inconsistency is specially marked when a wrist and hand and a forearm and wrist are printed on the same page or on facing pages

The authors in the preface emphasize that no attempt has been made to deal in depth with each bone disease It would appear however that the book will be of help to the radiologist in his daily work and provide sufficient information on a number of clinical and pathologic features

Nils P G Edling

L'EXPLORATION NEURORADIOLOGIQUE EN OPHTALMOLOGIE By P Guillot, H Saraux et R Sedan 784 pages and 650 illustrations Masson & Cie Éditeurs Paris 1966 Price 125 F

The importance and value of the methods of neuroradiologic examination in ophthalmology are emphasized in this book, the main contributions to which have been made by neuroradiologists Ophthalmologic collaborators have presented the special neuro ophthalmologic signs and syndromes that chould constitute indications for roentgen examination The book is introduced by a preface by H Fischgold who is mainly responsible for the neuroradiologic sections He discusses certain special problems and limitations of roentgenology He also outlines the requirements for the organization and administration of a purely neuroradio ophthalmologic department

The book consists of four sections The first describes the anatomical relationships between the visual pathways and blood vessels and the ventricular system and the cisterns from the eyeball to the occipital lobe it is well supported by illustrations of anatomical preparations Suggestions concerning suitable roentgenologic methods with the focus of the probable lesion as the starting point conclude this part

The second section deals with different neuroradiologic methods and the information they may yield Normal roentgen anatomy and pathologic conditions are described and conventional cerebral roentgenography angiography of the ophthalmic artery orbital venography vertebral angiography and angiography of the internal carotid are all discussed encephalography and ventriculography with oil and roentgen examination of the lacrimal ducts are also included This part ends with a discussion on isotope investigations of orbital tumours

The third section deals with neuroradiologic diagnosis in connection with special ophthalmologic findings such as exophthalmus chiasmal syndromes eye muscle pareses lateral homonymous hemianopsia unilateral papilledema and pathologic intrabulbar pressure

The fourth and final section of the book is devoted to complications in neuroradiologic examinations

In view of the wide field covered this book of about 770 pages and 650 figures including roentgenograms of high quality is one of the most comprehensive of its kind Ophthalmologic signs because of the extent of the visual pathways from the eye to the occipital lobe may involve the entire field of neuroradiologic diagnosis For this reason the book should without doubt be of great interest and value to neuroradiologists even though it may be primarily intended for the ophthalmologist

Herman Fodin

RADIOLOGY OF THE DUODENUM By R A Kemp Harper 225 pages and 110 figures Lloyd Luke London 1967 Price 45 shillings

The book contains a number of interesting cases of disorders of the duodenum but it seems a pity that only conventional barium studies have been made In a monograph limited to this particular region of the intestinal tract one could have wished that other methods had been mentioned including for example examinations of the paretic duodenum Despite this drawback however and because of the many good cases demonstrated by means of ordinary techniques the book may be recommended as a valuable aid in practice when diagnostic problems arise

J Frimann Dahl

ACTA RADIOLOGICA

OFFICIAL ORGAN OF THE RADIOLOGICAL SOCIETIES OF
DENMARK FINLAND NORWAY AND SWEDEN

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UROGRAPHY IN RELATION TO RENAL FUNCTION

by

O BARTLEY U BENGTSSON and S STATTIN

Roentgenologic investigation of the renal pelves and the ureters is essential in the majority of cases of established or possible disease of the urinary tract Either urography (intravascular injection of contrast medium) or pyelography (usually retrograde) may be performed If there are no contraindications the first mentioned examination is to be preferred since complications are less likely Conflicting opinions are found in the literature on whether or not urography provides information on renal function whether urography can be performed with good result when the renal function is reduced and if so what the lower limit may be and whether the contrast medium can cause or increase renal damage

The relation between renal function and the urographic findings has been studied by a number of investigators SIGGERS (1961) suggested that if films are obtained at an early stage e g a minute after the start of the contrast injection differences in the excretion rate may indicate unilateral arterial insufficiency EDLING et coll (1956) estimated the relation between contrast density and renal function and pointed out that good contrast density may occur with poor renal function and vice versa but they concluded that urography to a certain degree affords a qualitative indication of renal function In a later report EDLING et coll (1960) investigated a case of hyperparathyroidism and stated that careful

From Roentgen Department I (Director O Bartley) and Department II (Director I Wickbom) and Medical Department I (Director L Werko) Sahlgrenska Sjukhuset Gothenburg Sweden Submitted for publication 25 August 1967

L'EXPLORATION NEUROORADIOLOGIQUE EN OPHTALMOLOGIE By P Guillot, H Saraux et R Sedan 784 pages and 650 illustrations Masson & Cie Editeurs Paris 1966 Price 195 F

The importance and value of the methods of neuroradiologic examination in ophthalmology are emphasized in this book, the main contributions to which have been made by neuroradiologists Ophthalmologic collaborators have presented the special neuro ophthalmologic signs and syndromes that should constitute indications for roentgen examination The book is introduced by a preface by H Fischgold who is mainly responsible for the neuroradiologic sections He discusses certain special problems and limitations of roentgenology He also outlines the requirements for the organization and administration of a purely neuroradio ophthalmologic department

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J Frimann Dahl



Fig 2 a) Urography with contrast index (CI) grade 3 10 min after injection of the contrast medium in a 43 year-old woman with papillary necrosis b) Same case as in (a) Urography with contrast index grade 4 30 min after injection of the medium c) Urography with contrast index grade 5 in a normal case

ported that urography could be reliable even with reduced renal function SCHWARTZ et coll (1963) obtained satisfactory urographies with serum creatinine values of over 3 mg % FRIEDENBERG & CARLIN (1964) employed increased amounts of contrast medium and found that the diagnosis without appreciable risk could be improved in this manner The majority of the authors are however of the opinion that urography cannot give detailed information in renal insufficiency CAMPBELL (1961) for example stated that good urographic results can not be attained when the non protein nitrogen value is over 50 mg % CAFFEY (1961) set the limit at 60 mg % while OLSSON'S (1962) experience was that with clearance values below 40 % the excretion of the contrast medium is so poor that the examination can offer no diagnostic information This value would represent a serum creatinine level of approximately 2.5 mg % DANSGAARD & HORNES expressed a similar opinion and suggested a limit value of 2 0 mg %

AXWALL et coll (1955) and PENDERGRASS et coll (1958) stated that there is increased risk with urography in patients with renal insufficiency This is particularly true in the presence of reduced liver function or severe general disease

The urographic techniques and tests of renal function have varied in the cited reports some of the authors have moreover not clearly defined renal insufficiency In order to clarify the questions presented in the introduction the present authors

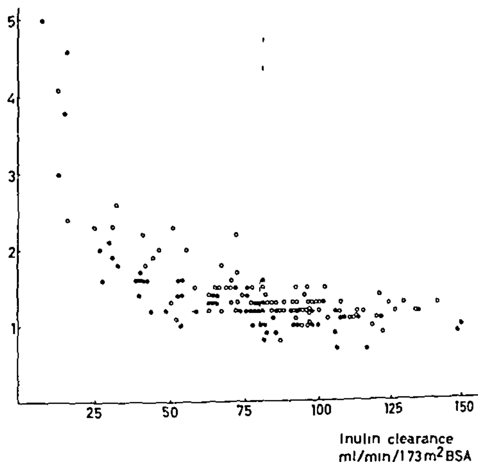


Fig. 1. The relationship between serum creatinine concentration (according to Bonsnes & Taussky) and the inulin clearance in 200 patients with renal disease with or without hypertension. Dotted lines indicate arbitrary normal limits (after Bengtsson et coll. 1964).

urographic examinations producing poor contrast filling in young and middle aged patients not suffering from polyuria or circulatory failure suggest reduced renal capacity. Squire & Schlegel (1959) investigated patients with hypertension in whom the first urographic film was obtained five minutes after the start of the injection. They found that function discrepancies between the two kidneys up to the order of ten could exist without any differences being evident at urography. They therefore suggested that urography affords a poor test of renal function. Winter (1960) and Dalsgaard & Hornes (1963) supported this view.

McEwan et coll. (1962) examined infants (under one year of age) and re



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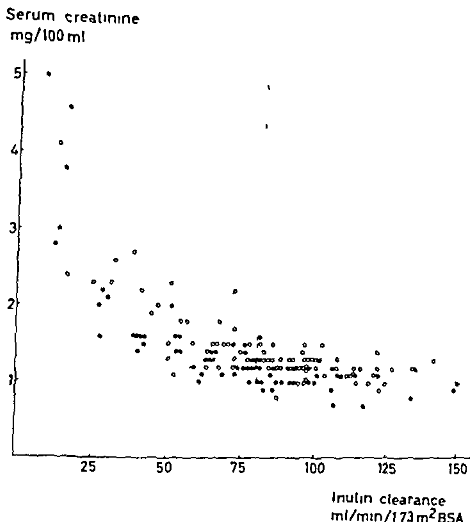


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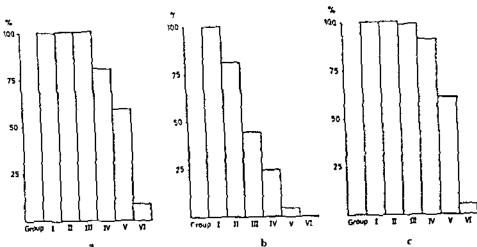


Fig 3 a) Frequency of patients with contrast excretion at 3 min after start of the injection distributed according to the serum creatinine grouping b) Frequency of CI grade 5 in each renal function group c) Frequency of CI grade 3 5 in each renal function group

Grades 3 4 and 5 are illustrated in Fig 2 Grade 3 is the minimum rating which permits diagnostic evaluation of the urogram

Results

The frequency of visible contrast medium at 3 min after the contrast medium injection is presented in Fig 3a All of the patients in groups I to III i e patients with serum creatinine values up to 2 0 mg % had contrast excretion at this time The frequency diminishes however in the groups with increasing serum creatinine values i e 81 % for group IV The difference between groups I to III on one hand and group IV on the other is statistically significant as is also the difference between respectively groups IV and V and VI

The contrast indices as means of the renal function groups are presented in Fig 4 It can be seen that the higher the serum creatinine value the lower the contrast index The differences between groups I and II and between groups II and III at 3 min are not statistically significant Groups I and II do not differ significantly at 6 min unlike the other groups at this time and unlike the groups at 10 min and 15 min

The results in regard to the frequency of CI 5 in the various renal function groups are given in Fig 3b All of the 23 patients in group I were rated CI 5 as were 28 of 34 in group II 14 of 32 in group III 8 of 33 in group IV, one

have studied with uniform techniques a urographic material in which the renal function has varied

Material and Methods The material comprised 161 adults, 60 men and 101 women, the mean ages being 56 and 50 years, respectively Urography was performed in all, and the serum creatinine concentration was utilized as an index of renal function The creatinine was determined within a week before urography The tests were usually repeated

Determination of the serum creatinine was carried out by the method of BONSNES & TAUSSKY (1945) Correlation between serum creatinine levels and glomerular filtration rate is presented in Fig 1 A value of 1 2 mg % is in our hospital considered as the upper normal limit We have recently measured the serum creatinine with the autoanalyzer Technicon Values which on the average were 0 3 mg % lower than with the other method were then obtained (HOLLENDER), and for this reason a corresponding correction has been applied

The material has been divided into six groups in relation to the serum creatinine levels and according to the distribution given below

Group	Number of *patients*	Serum creatinine in mg %	
		Range	Mean
I	23	0 9 – 1 2	1 1
II	34	1 3 – 1 6	1 4
III	32	1 7 – 2 0	1 8
IV	33	2 1 – 2 6	2 3
V	23	2 7 – 3 3	3 0
VI	16	3 4 – 5 5	3 9

Urography was performed according to our standard method by injection of 40 ml Urografin 60 %, and with ureteral compression Films were obtained at 3 6, 10 and 15 *min after the start of contrast injection* and thereafter when necessary at 5 to 15 min intervals Ureteric compression was applied immediately after the 6 min film

The evaluation of the urograms was based on contrast filling and contrast density These two factors have been combined as a contrast index (CI), and graded 1 to 5

CI 1 — very thin contrast in the pelvis not permitting interpretation,

CI 2 — thin contrast allowing detailed interpretation of the renal pelvis ampulla but not of the calyces,

CI 3 — contrast density low but a number of calyces can be judged,

CI 4 — moderate contrast density and all of the calyces can be judged,

CI 5 — high contrast density and filling

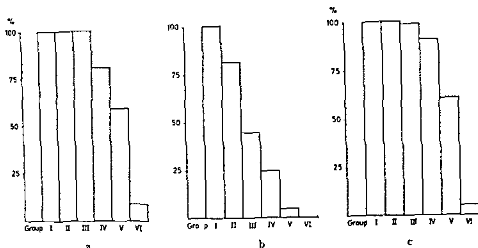


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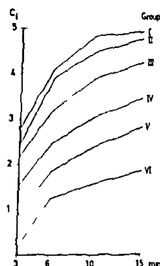


Fig 4 Mean contrast index (CI) for each renal function group at different times of exposure after the start of injection

of 23 in group V, and none of the 16 patients in group VI The differences between the groups are statistically significant with the exception of the difference between groups III and IV

The mean time for attaining CI 5 was shortest for group I, namely 11 7 min, it was 14 7 min for group II 18 9 min for group III, and 23 8 min for group IV These differences between the groups, except between groups III and IV, are statistically significant

As earlier mentioned CI 3 to CI 4 should be suitable for satisfactory urography The frequency of CI 3 5 (Fig 3c) in the various renal function groups was as follows 100 % for groups I and II, 97 % for group III, 91 % for group IV, 61 % for group V, and 6 % for group VI Diagnostic urography according to our definition was thus attained in almost two thirds of the patients with serum creatinine values between 2 7 and 3 5 mg %

Discussion

An investigation of this sort is accompanied by a number of sources of error such as fall in blood pressure, varying degrees of dehydration variable size of the renal pelves, faulty ureteral compression and discrepancies in timing and exposure Furthermore, estimation of the contrast index is prone to subjective variation

Patients with a fall in blood pressure were excluded All patients were deprived of fluid for 10 to 12 hours before the examination even so the degree of dehydration could have varied Patients with hydronephrosis were excluded The adequacy of ureteral compression would at the earliest, influence the contrast filling discernible after 10 minutes Patients in whom effective compression could

not be attained were excluded The error of timing did not exceed one minute and the voltage was maintained as close to 75 kV as possible The mA/sec varied because automatic exposures were usually employed

The use of a contrast index was intended to provide as objective a classification of the films as possible The ratings were based on two factors of which the contrast filling could be estimated more definitively the evaluation of contrast density on the other hand was more subjective and could moreover have been influenced by film quality development procedure and the shape of the patient This source of error should be of little importance for the evaluation was in about twenty five per cent of patients made independently by two radiologists who arrived at the same results Even if several steps in the method employed could have influenced the interpretations there is no reason to assume that these could have been overrepresented in any particular function group The entire material was examined within a period of about two weeks

Contrary to previous reports most of the present results indicate that urography provides a remarkably good indication of renal function This was exemplified by the almost consistent statistically significant differences between the function groups This was true in regard to the contrast index at different times during urography as well as to the frequency of index CI 5 A study of the frequency of contrast medium excretion at 3 min after start of injection revealed however no differences between groups with erum creatinine up to 2 0 mg % wherea a difference was noted above this level This finding probably depends on the technique employed If the technique had been modified by the use of a small amount of contrast medium and exposures made at shorter intervals after commencement of injection even the groups with serum creatinine values under 2 0 mg % would in all probability have been possible to differentiate This assumption is supported by the observation of OLSSON (1962) who stated that urography with estimation of the excretion rate provides information on renal function

The contrast index in all of the function groups varied within moderately wide limits at the 3 min films probably due to variations in dehydration as well as to the relative unreliability of the timing There was more conformity in the ratings of the subsequent films

The results are based on group mean values and the values within each group except for the 3 min films disclosed very little spread Ratings of only a few patients deviated from the group means Subsequent controls of these patients revealed in contrast to those in majority variability of the serum creatinine level At urography in five patients for example the creatinine values were between 1 6 mg % and 2 5 mg % but a few weeks later these levels had risen to between 2 8 mg % and 5 3 mg % The urographic findings in these patients

essentially corresponded to those in patients with the higher creatinine levels. One patient was re-examined *after reaching a clinically steady* state and the urographic findings then matched those associated with the actual serum creatinine value.

Another patient with a serum creatinine level of 3.0 mg % was examined and found to be the only one in group V with a CI 5. Three weeks later, however, the creatinine level had fallen to 2.0 mg %, and further urography performed during the subsequent steady state revealed results which were almost identical to those obtained on the initial occasion with the high creatinine level. In these instances urography offered a better indication of the actual renal function than the serum creatinine level. The findings for these six patients with changing renal function seem to indicate a lag in the serum creatinine change.

A high concentration of contrast medium is not necessarily advantageous for diagnostic purposes: it may in point of fact hinder the interpretation. Non-opaque concrements and small tumours may be masked and tubular stasis may be difficult to differentiate from, for example, a so-called medullary sponge kidney or papillary necrosis.

FRIEDENBERG & CARLIN have in routine urography adjusted the contrast medium dose to body surface area. They also pointed out that comparatively large amounts of medium often permit diagnostic urography in renal insufficiency. Meanwhile it might be advisable to determine the amount of contrast medium to be injected in relation to the renal function of the patient. Tri-iodide *contrast media are excreted almost entirely by glomerular filtration* (MCCHESNEY & HOPPE 1957). A comparatively good estimate of the filtration rate is obtained *by testing the serum creatinine value*. *The test* is simple and gives more reliable information than the determination of the non-protein nitrogen. A serum creatinine value of 2.0 mg % corresponds to a glomerular filtration rate of about 50 %, while a value of 3.0 mg % approximates to 25 % of the normal. With normal kidney function, no more than 20 ml contrast medium are required for satisfactory urography. If the amount is doubled or quadrupled in relation to the aforementioned reduced filtration rates, the urinary tract can probably be studied with better result. This assumption is based on our experiences with a fair number of patients. For example, diagnostic urography was attained with 60 to 80 ml Urografin 60 % in two patients with papillary necrosis *without* calcifications (serum creatinine 4.5 mg % and 4.7 mg %, respectively), and in one patient with congenital polycystic kidney disease (*serum creatinine* 4.4 mg %). Another patient had severe uremia with a serum creatinine value of 13.6 mg % and a *calcification on the left side* in the true pelvis, urography was performed with 100 ml Urografin 60 % and the ureters were so well filled that a ureteric calculus could be excluded. When large amounts of medium were

injected excretion occurred 3 min after commencement of injection even in a number of patients with severe renal insufficiency This observation points to the connection between early excretion and the amount of medium injected

The present tri iodide contrast media have a lower toxicity than the earlier types of media It is maintained in the literature that the contrast medium may cause renal damage such reports are however relatively few and generally refer to the old more toxic media An investigation is under way to estimate whether the newer media damage the kidney or increase already demonstrable renal damage For this purpose renal function studies have been performed before and after urography and angiography with large quantities of contrast medium (BARTLEY et coll BENGTSSON et coll 1968) There is so far no indication of reduced renal function either in regard to glomerular filtration rate or concentrating capacity

SUMMARY

Urography was performed by a uniform method in 161 patients and the excretion rate contrast filling and contrast density were determined The patients were divided into six groups according to their serum creatinine levels Diagnostic urography may be attained in the majority of patients with serum creatinine levels slightly above 3 mg No indications of renal damage due to large amounts of contrast medium were noted

ZUSAMMENFASSUNG

Bei Anwendung der Standardmethode wurde Urographie an 161 Patienten vorgenommen und die Ausscheidungsrate Kontrastfullung und Kontrastdichte wurden festgestellt Die Patienten wurden in 6 Gruppen je nach der Kreatininkonzentration in Serum eingeteilt In der Mehrzahl der Patienten in denen die Kreatininkonzentration etwas uber 3 mg lag war es moglich diagnostische Urograph en zu erhalten Indikationen von Nierenschadigungen wurden trotz grosser Menge Konstrastmittel nicht beobachtet

RÉSUMÉ

Les auteurs ont fait de urographies avec une technique uniforme chez 161 malades et ils on determiné le taux d excretion l opacification et la densite du contraste et ont réparti leur malades en six groupes d apres le taux de creatinine serique Cette methode permet d obtenir une urographie utilisable pour le diagnostic chez la majorite des malades qui ont un taux de creatinine un peu superieur à 3 mg %. Les auteurs n ont pas constate de signe de trouble renal du aux grandes quantites de moyen de contraste

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FROM THE ROENTGEN DEPARTMENT (DIRECTOR H. LARSSON), THE CHILDREN'S HOSPITAL, GOTHENBURG, SWEDEN

ROENTGENOLOGIC INVESTIGATION OF THE NASOPHARYNGEAL TONSIL IN CHILDREN OF DIFFERENT AGES

by

SVERRIR JOHANNESSON

Many otolaryngologists and pediatricians maintain that the methods employed clinically for estimating the volume of nasopharyngeal lymphoid tissue in children, i.e. the size of the so-called nasopharyngeal tonsil, are in many ways troublesome and unsatisfactory. The method most often employed, palpation through the mouth, is usually distressing, particularly for young patients. In many instances it is difficult to ascertain whether the findings thus established are pathologic; it is impossible to carry out *anterior* or posterior rhinoscopy if the patient is not cooperative.

Roentgen examination may reveal the size of the nasopharyngeal airway and the quantity of lymphatic tissue within it. The simplest way to perform the examination in children is to take a single lateral film of the nasopharynx. GOLDMAN & BACHMAN (1958) stated: "Our experiences have revealed that the information obtained by radiography of the nasopharynx is usually more complete and accurate than that obtained by other methods and can be related to the surgical scope when operation is indicated."

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greatest from 6 to 7 years of age at which time regression begins this is usually completed by the 10th year TESTUT (1923) stated that maximum development of this structure takes place from 12 to 14 years of age and involution occurs between 20 and 25 years GRAFF maintained that the volume of the nasopharyngeal tonsil increases year by year until the age of about 10 when it usually diminishes and an involution of the lymphoid tissue can be histologically demonstrated

Roentgen examination of the nasopharynx in the lateral projection is carried out most easily with the child supine and a horizontal beam (CLIFFORD et coll WEITZ) A true lateral view is needed for optimum evaluation of the soft tissue in the roof of the nasopharynx During exposure the child should breathe through the nose as otherwise the space in the lower part of the nasopharynx may become obliterated due to the elevation of the soft palate and he soft tissue outline would then be lost In the infant it may be necessary to close the mouth so as to force nasal breathing

The roentgenograms thus obtained will depict the nasopharyngeal *tonsil* as a soft tissue mass in the roof of the nasopharynx which usually curves down ward into the nasopharyngeal airway Posteriorly it cannot be differentiated from pre vertebral soft tissue and anteriorly it is defined by the choanae The thickness of the nasopharyngeal tonsil is taken to be the distance between the bony roof and the nasopharyngeal airway The lobe of the ear is *sometimes* superimposed on the airway in the nasopharynx and must therefore be dif ferentiated from the nasopharyngeal soft tissues

According to GOLDMAN & BACHMAN investigation of the nasopharyngeal tonsil with tomography or contrast media does not provide more information than can be obtained with lateral films of the area WEITZ and DE LORIMER *et coll* and GOLDMAN et coll have stated that pathologic enlargement of the naso pharyngeal *tonsil* in the majority of children occurs when the width of the soft tissue *in the* nasopharyngeal roof exceeds 6 to 7 mm These figures were however not related to the children s age nor was the method of measurement described

Material and Method Our series consisted of 140 children 90 boys and 50 girls in ages between 3 *months* and 15 years examined between October 1964 and May 1965 The children were clinically free from infection of ear nose throat and chest The case histories revealed no special disposition to infection or any allergic disease of the respiratory tract

The roentgenologic examinations of the paranasal sinuses which were per formed in all the children except the youngest were normal and so were the



Fig 1 Normal nasopharynx in a 10 year old boy The thickness (width) of the nasopharyngeal tonsil is 13 mm

A number of articles have been published on the roentgenologic diagnosis of enlarged nasopharyngeal tonsil adenoid vegetations (CLIFFORD et coll 1944 GENZ 1954, GOLDMAN & BACHMAN 1958, GROTH 1933 DE LORIMIER 1954, and WEITZ 1946) The majority of authors related the size of this structure to the age of the child but the literature is indefinite as to the normal limits of size in relation to age

The present investigation was an attempt to determine the normal variations in size of the nasopharyngeal tonsil in children of different ages, as measured in lateral roentgenograms of the nasopharynx

Anatomy The nasopharynx lies above the soft palate and behind the choanae and the posterior edge of the vomer The roof is formed by a part of the lower surface of the body of the sphenoid bone, the spheno occipital synchondrosis, and that portion of the basilar process of the occipital bone which is situated in front of the pharyngeal tubercle The latter comprises the attachment of the pharyngeal raphe which, with the pharyngobasilar fascia and a part of the superior pharyngeal constrictor muscles, form the posterior wall of the naso pharynx The roof slopes backwards and downwards into the posterior wall In children the mucous membrane of the roof of the nasopharynx and to a certain extent that of its posterior wall, are often abundantly infiltrated by the lymphoid tissue which constitutes the nasopharyngeal tonsil The lymphoid tissue is thickest in the ventro cranial part of the nasopharynx (GRAFF 1953) Adenoid tissue in the nasopharynx is present at birth, reports concerning its subsequent development are controversial

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means are not significant When the results for the 2 to 15 year old children were combined the mean width was 13 4 mm No difference was observed between the values for boys and those for girls

Discussion

The investigation revealed that the mean thickness of the nasopharyngeal tonsil increased from 7 5 mm for the group of children under the age of 1 year to 10 0 mm for the 1 year age group Only minor changes in size were observed between the ages of 2 to 15 years The means for these age groups ranged from 12 0 to 14 3 mm These figures for children with no overt respiratory tract disease are high in comparison with the results in the aforementioned reports in which it is maintained that the nasopharyngeal tonsil is pathologically enlarged when the width of the soft tissue in the roof of the nasopharynx exceeds 7 mm

Graff among others has pointed out that many poorly understood and insufficiently investigated factors influence the development of lymphoid tissue in the nasopharynx Our limited understanding of these factors (for example the effect of climatic conditions) necessitates great caution in the interpretation of data on the development of lymphoid tissue in the nasopharynx of subjects of different national and geographical backgrounds

SUMMARY

Roentgenologic examination of the nasopharynx was performed in 140 children without evidence of respiratory disease and in ages varying between 3 months and 15 years The thickness of the soft tissue outline was measured on lateral roentgenograms It was found to increase during the first two years of life and thereafter remained practically unchanged

ZUSAMMENFASSUNG

Bei rontgenologischer Untersuchung von 140 Kindern im Alter von 3 Monaten bis 15 Jahren und ohne offenbare Erkrankung der Luftweg wurde die Dicke der Nasopharynxtonsille auf die laterale Rontgenogramme gemessen Wahrend der ersten zwei Lebensjahre nimmt die Dicke zu und bleibt danach praktisch unverandert

RÉSUMÉ

L auteur a fait un examen radiologique du nasopharynx chez 140 enfants ages de 3 mois jusqu aux 15 ans qui ne presentaient pas de signe d affection respiratoire Il a mesure l epaisseur des tissus mous sur les radiogrammes laterales Elle augmente au cours des deux premieres annees de la vie puis reste a peu près sans changement

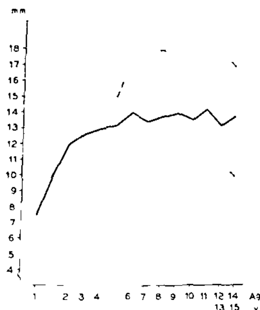


Fig 2 Graph depicts the greatest width of the soft tissue in the nasopharyngeal roof in relation to age Each point of the solid curve is the mean of measurements made in 10 children The ranges are indicated by broken curves

routine blood tests A true lateral roentgenogram of the nasopharynx was obtained with horizontal beam and the child supine The cassette was placed close to the head of the child, at focus-film distances between 74 and 78 cm and the films were exposed during nasal respiration The greatest width of the soft tissue outlined anterior to the site of the pharyngeal tubercle was measured on the films perpendicular to the bony roof of the nasopharynx (Fig 1) In no instance did the contour of the soft tissue corresponding to the nasopharyngeal tonsil present more than moderate convexity as opposed to the greater convexity usually associated with a pathologic condition

Results

The measurements of the soft tissue outlines on the lateral roentgenograms of the nasopharynx are summarized in Fig 2 The solid curve represents the means of the measurements of the 10 children in each age group The ranges of the values are indicated by the broken lines

The mean width of the soft tissue for the group under one year was 7 5 mm (range 5 to 11 mm) and that for the group of one year olds was 10 mm (range 6 to 13 mm) This difference in mean width is statistically significant and these groups had significantly lower means than all of the other The subsequent means increase slightly from 12 0 to 14 0 mm through age 6 and thereafter vary between 13 2 mm and 14 3 mm up to age 15 The differences between these

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THE PATH OF THE ULTRASONIC BEAM IN CLINICAL ECHOENCEPHALOGRAPHY

by

R HORENSTEIN A PERSSON A WENNBERG and L WIDEN

Determination of the position of the midline structures of the brain by means of the ultrasonic technique (echoencephalography) first introduced by LEKSELL (1955, 56) has proved of great value in the diagnosis of intracranial expanding processes (see e g JEPPSSON 1961 LITHANDER 1961 BARROWS et coll 1965) and also of hydrocephalus in children (LITHANDER 1961), and in adults (FORD & McRAE 1966 KAZNER & SCHIEFER 1966) Its usefulness in the differential diagnosis of intracerebral haemorrhage and cerebral infarction (ACHAR et coll 1966 WIDEN et coll 1967) has also been demonstrated Despite the extensive use of the method opinions differ with regard to which structure or structures give rise to the so-called midline echo (M echo) LEKSELL and later JEPPSSON stated that the primary source of the M echo is the pineal body while other authors (e g LITHANDER and FORD & AMBROSE 1963) suggested that the M echo comes from the third ventricle the longitudinal fissure or the septum pellucidum The present investigation was undertaken to ascertain whether combined echoencephalographic and roentgenographic studies would permit determination of the structure or structures responsible for the M echo in living man

Submitted for publication 21 June 1967

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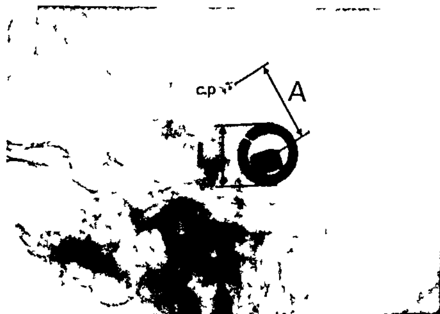


Fig 1 Skull roentgenogram in Case 10 A — distance between the pineal body (c p) and the point of intersection of the central beam of the ultra sound bundle with the midsagittal plane determined by the projection of the lead indicators in the roentgenogram Iy —diameter of the projection of the lead indicator nearest to the roentgen tube

Material and Methods The investigations were performed in ten patients aged 30 to 55 years, referred to the roentgen department In six of these ordinary skull films had revealed a calcified pineal body The remaining four patients were to undergo pneumography In all of them the conventional films were normal

The ultrasonic technique was essentially the same as the one described by JEPPSSON the instrument being a Krautkramer USIP/9 and the operating frequency 2 Mc s the transmitter crystal was 24 mm in diameter The transmitter was applied to the right temporal region, vertically just above the tip of the pinna and adjusted so as to obtain a typical M echo of the greatest possible amplitude A check was made that the echo, although of lower amplitude persisted on a ± 5 mm movement of the transmitter in horizontal or vertical direction Without altering the position of the transmitter, a receiver crystal (24 mm in diameter) was then applied to the opposite side and adjusted until the impulses received were also maximal A further control was made to see that the response, although of lower amplitude persisted on moving the crystal ± 5 mm in horizontal and vertical directions The centre of each crystal was marked on the scalp with a lead indicator ring shaped on one side and punctiform on

the other held in position with adhesive tape or collodion The fact that the point of exit of the ultrasonic beam was determined with a receiver crystal and not for example with a mechanical device such as an indicator arm perpendicular to the surface of the transmitter made it possible to ignore refractive effects caused by lack of parallelism of the surfaces of the inner and outer tables of the skull nearest to the transmitter

The position of the head was adjusted so that the lead indicators were projected one upon the other with the aid of an image intensifier The central beam of the roentgen tube was then directed through the indicators The distance between identifiable structures chiefly the pineal body and the projection of the lead indicators was measured on the roentgenograms The value of A in Fig 1 which may be regarded as representing the distance between the central beam of the ultrasound bundle and the pineal body was calculated from the formula

$$A_{corr}=\frac{A(I_R+I_M)}{2\,I_M}$$

where I_R is the true diameter of the lead indicator nearest to the roentgen tube and I_M the diameter of its projection in the roentgenogram

Results

The site of intersection of the central beam of the ultrasound bundle with the midsagittal plane in each of the ten patients is shown in Fig 2 In the patients for whom ordinary skull films were obtained the location of these points was determined with the pineal body and the sella turcica as reference points On the pneumograms other reference points e g the third ventricle and the Sylvian aqueduct could of course be used in addition to the aforementioned ones

As shown in the table below the distance between the point of intersection and the pineal body varied greatly

Case No	Examination	A_{corr} in cm
1	Pneumography	2 7
2	Pneumography	0 8
3	Pneumography	3 2
4	Ordinary skull films	1 2
5	Ordinary skull film	1 2
6	Ordinary skull film	2 1
	Ordinary skull films	2 6
8	Ordinary skull films	0 4
9	Pneumography	1 2
10	Ordinary skull films	1 9

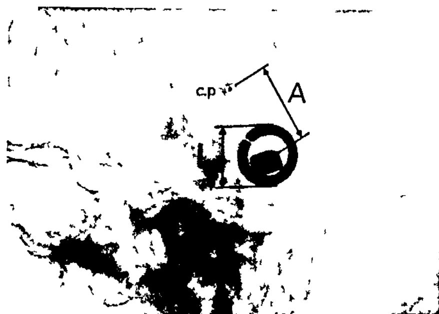


Fig. 1. Skull roentgenogram in Case 10. A — distance between the pineal body (c.p.) and the point of intersection of the central beam of the ultrasound bundle with the midsagittal plane, determined by the projection of the lead indicators in the roentgenogram. Dt — diameter of the projection of the lead indicator nearest to the roentgen tube.

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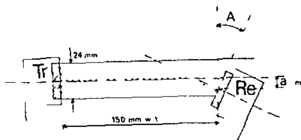


Fig 4 The experimental set up for determining the effect on the amplitude of the ultrasound impulse of lateral displacement and rotation of the receiver Tr—transmitter Re—receiver

It may be assumed that in the ideal case the structures producing the M echo are situated at the points indicated in Fig 2 The following must however be taken into account in the evaluation of the results shown in the figure The ultrasound consists not of a single ray but must under the given conditions be regarded as a cylindrical bundle of parallel rays in the near field Its perpendicular intersection with the sagittal plane does not occur at a single point but within an approximately circular area within which the structure producing the M echo is situated Similarly the exit of the ultrasound from the skull on the side opposite to the transmitter does not occur at a single point but within a more or less circular area Model experiments were carried out to determine the magnitude of the effects of these factors on the results

1 The transmitter crystal was placed in firm contact with the outer surface of a thin walled glass bowl filled with water A circular plane plastic object 4 mm in diameter was fixed in a stereotaxic instrument (Baltimore Instrument Co) and lowered into the water with its plane surface parallel to and 75 mm from the crystal The object could be moved perpendicular to the ultrasonic beam along the horizontal scale of the stereotaxic instrument (see the schematic diagram to the right in Fig 3) It is indicated in Fig 3 that the amplitude of the echo (R_{ampl}) was largest when the centre of the object was in the path of the central beam of the ultrasound bundle ($a = 0$) Furthermore the R_{ampl} decreased rapidly when the object was moved laterally and was only about 10 % of the R_{ampl} maximum when $a = 10$ with the whole object still in the path of the ultrasound bundle No echo was obtained when $a > 12$ mm which confirms the correctness of the assumption that the ultrasound consists of a bundle of parallel rays of the same radius (R) as that of the transmitter crystal i e 12 mm This implies that the circular area in the midsagittal plane within which the structure producing the M echo must be situated has a radius of ≤ 12 mm i e $\leq$ the radius of the transmitter crystal

2 The transmitter was placed in firm contact with a water filled rubber

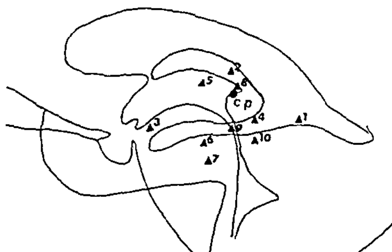


Fig 2 Distribution of the points of intersection of the central beam of the ultrasound bundle and the mid sagittal plane in ten subjects

Fig 3 Amplitude of the echo (R_{ampl}) as a function of the distance a between the object producing the echo and the central beam of the ultrasound bundle On the right the experimental set up is shown schematically Tr—transmitter Re—receiver B_T—transmitted ultrasound bundle B_R—ultrasound bundle reflected from the object

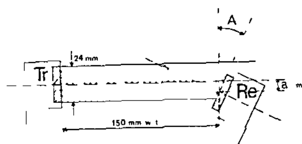


Fig 4 The experimental set up for determining the effect on the amplitude of the ultrasound impulse of lateral displacement and rotation of the receiver Tr—transmitter Re—receiver

It may be assumed that in the ideal case the structures producing the M echo are situated at the points indicated in Fig 2 The following must however be taken into account in the evaluation of the results shown in the figure The ultrasound consists not of a single ray but must under the given conditions be regarded as a cylindrical bundle of parallel rays in the near field Its perpendicular intersection with the sagittal plane does not occur at a single point but within an approximately circular area within which the structure producing the M echo is situated Similarly the exit of the ultrasound from the skull on the side opposite to the transmitter does not occur at a single point but within a more or less circular area Model experiments were carried out to determine the magnitude of the effects of these factors on the results

1 The transmitter crystal was placed in firm contact with the outer surface of a thin walled glass bowl filled with water A circular plane plastic object 4 mm in diameter was fixed in a stereotaxic instrument (Baltimore Instrument Co) and lowered into the water with its plane surface parallel to and 75 mm from the crystal The object could be moved perpendicular to the ultrasonic beam along the horizontal scale of the stereotaxic instrument (see the schematic diagram to the right in Fig 3) It is indicated in Fig 3 that the amplitude of the echo (R_{mpl}) was largest when the centre of the object was in the path of the central beam of the ultrasound bundle ($a = 0$) Furthermore the R_{mpl} decreased rapidly when the object was moved laterally and was only about 10 % of the R_{mpl} maximum when $a = 10$ with the whole object still in the path of the ultrasound bundle No echo was obtained when $a > 12$ mm which confirms the correctness of the assumption that the ultrasound consists of a bundle of parallel rays of the same radius (R) as that of the transmitter crystal i e 12 mm This implies that the circular area in the midsagittal plane within which the structure producing the M echo must be situated has a radius of ≤ 12 mm i e $\leq$ the radius of the transmitter crystal

2 The transmitter was placed in firm contact with a water filled rubber

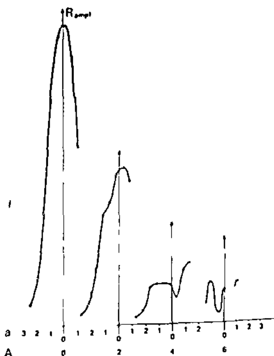


Fig 5 Amplitude of impulse received (R_{ampl}) as a function of the position of the receiver in the ultrasound bundle for different values of angle A (cf fig 4)

balloon 150 mm in diameter The receiver was applied to the opposite side of the balloon and mounted in the stereotaxic instrument It could be moved laterally along the graded scale as well as rotated on an axis perpendicular to the central beam of the ultrasound bundle (Fig 4) As seen in Fig 5, the amplitude of the impulses received (R_{ampl}) was largest when the centre of the receiver crystal was in the path of the central beam ($a = 0$) and its surface at right angles to the beam ($A = 0°$) Rotation of the receiver 2° reduced the amplitude of the impulses (R_{ampl}) by about 50 % (cf DENIER VAN DER GON et coll 1966) A 6° rotation reduced the R_{ampl} to $<$ 10 % of the R_{ampl} maximum The figure

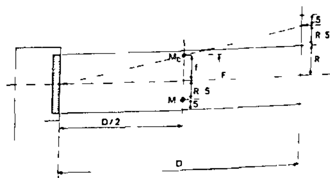


Fig 6 Diagram for calculation of distance F
$f = (R + (R-5))/2 = R - 2.5$
$F = R - 5 + f = 2R - 7.5$
if $R = 12$ then $F = 16.5$

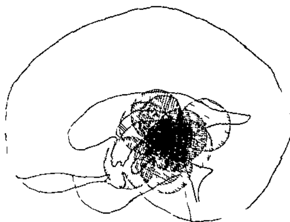


Fig 7 Diagram showing the points indicated in fig 2 having been replaced by circles with a radius of 16 5 mm

also shows that when a > 24 mm the R pl is 10 % of the R mpl maximum which implies that the circle within which a measurable signal can be obtained with the type of transmitter and receiver used has a radius not exceeding 24 mm (= 2 R)

Fig 6 is a schematic diagram of the situation when the position of both the object and the receiver is the most unfavourable i e when the error caused by the combination of the factors referred to under (1) and (2) is maximal The true position of the structure producing the M echo (M) is then at distance F from the point at which the central beam is assumed to intersect the midsagittal plane (M)

It is theoretically possible according to Fig 3 for M to be R distance from the central beam but since checks at the echoencephalographic examinations indicated that the M echo persisted when the transmitter was moved ± 5 mm in horizontal or vertical direction M cannot be at a distance greater than R — 5 from the central beam Likewise the point of exit of the central beam determined by mean of the receiver on the opposite side of the skull cannot deviate from the true point of exit by more than R + (R — 5) Accordingly distance F in Fig 6 may be calculated to be 16 5 mm

Comments and Conclusion

The results of these model experiments and the calculations based on them indicate that in each of the cases examined the structure producing the M echo may be situated anywhere within a circle with a radius of 16 5 mm and the centre at the roentgenographically determined point at which the central beam intersects the mid sagittal plane

As indicated by the values tabulated on p. 307, $A_{c\ rr}$ was in five cases greater than 1. In these five cases, the pineal body can consequently be excluded as the source of the M echo. In a further three cases (in which $A_{c\ rr} = 1.2$) the probability of the pineal body being the source of the M echo was very small. In Fig. 7 the points of intersection depicted in Fig. 2 have been replaced by circles with a radius of 16.5 mm. The figure clearly shows that these ten cases have no single point in common. This means that no single structure can be said to be the sole source of the M echo. On the other hand, the series is too small to determine whether any structure significantly more often than any other is the source of the M echo.

Acknowledgement

We wish to thank Prof. T. Greitz, Department of Neuroradiology, Karolinska sjukhuset, and Mr. S. Wennerberg, Chief Research Engineer, Research Institute of the Swedish National Defence, for valuable suggestions.

SUMMARY

The path of the ultrasonic beam in echoencephalography was investigated in ten adult subjects. The point of intersection of the central beam and the midsagittal plane was determined in roentgenograms. The inherent errors of method were analysed in model experiments. The results indicate that no single structure can be said to be the sole source of the M echo. The pineal body could be excluded as the source of the M echo in five subjects and in three was highly improbable.

ZUSAMMENFASSUNG

Der Strahlengang eines Ultraschallbündels wurde bei Echoencephalographie an 10 Erwachsenen untersucht. Der Schnittpunkt des Zentralbündels und der sagittalen Mittelebene wurde mit Hilfe von Röntgenbildern ermittelt und Methodikfehler wurden mittels Modellexperimente untersucht. Es ergab sich, dass keine einzelne Struktur für das Mittelecho verantwortlich sein konnte. Es wurde festgestellt, dass die Zirbeldrüse in fünf Fällen nicht verantwortlich war und in drei Fällen war deren Rolle in dieser Hinsicht unwahrscheinlich.

RÉSUMÉ

Les auteurs ont étudié le trajet du faisceau d'ultra-sons en écho-encéphalographie chez dix adultes. Ils ont déterminé sur des radiographies le point d'intersection du faisceau central avec le plan sagittal médian. Ils ont étudié par une expérimentation sur des modèles les possibilités d'erreur de cette méthode. Les résultats de ces expériences montrent qu'aucune structure ne peut être considérée comme la source unique de l'écho M. L'épiphyse a pu être exclue comme source chez cinq sujets et chez trois son rôle était hautement improbable.

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FROM THE DEPARTMENT OF RADIOLOGY (DIRECTOR PROF. H. TACHIIRI), OSAKA UNIVERSITY MEDICAL SCHOOL, OSAKA, JAPAN

ANEURYSM ASSOCIATED WITH AORTITIS SYNDROME

by

T. KOZUKA, I. NOSAKI, K. SATO and H. TACHIIRI

The aortitis syndrome, pulseless disease or atypical coarctation of the aorta consists of extensive lesions involving the brachiocephalic arteries and the pulmonary arteries in addition to the aorta and its main tributaries (INADA et coll., KOZUKA et coll. and UEDA et coll.). Stenoses or obstructions of the arterial system with or without dilatation of the ascending aorta, and a few aneurysms (GROLLMAN et coll., KOZUKA et coll. and WAKISAKA et coll.) have also been reported. The purpose of this paper is to present 7 cases of the aortitis syndrome with aneurysms of the aorta and brachiocephalic arteries and to emphasize the close relationship of the syndrome and such aneurysms.

Material and Methods. Conventional roentgenography and aortography have been performed in 53 females and 7 males of Japanese stock, in ages from 10 to 52 years. Aneurysms were demonstrated in 7 cases, two of which had been reported upon before. The aneurysms were in five cases detected by conventional roentgenography of the chest and in only two cases by aortography.

Percutaneous retrograde aortography was performed to delineate the extent and character of the vascular lesions. Pressure injection of the contrast medium was made to outline the thoracic aorta, the tip of the catheter being placed in

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Fig 1 Case I Aneurysm of the proximal part of descending aorta partially filled with contrast medium Aneurysmal dilatation of the lower third of the descending aorta

the middle part of the ascending aorta By this method the whole of the thoracic aorta including its origin could be demonstrated Transvenous aortography had to be employed when the insertion of the catheter into the ascending aorta failed

Case reports

Case I Male aged 27 with cough and blood stained sputum Roentgenography of the chest revealed a semispherical mass protruding from the left aspect of the superior mediastinum and continuing distally apparently to the descending thoracic aorta The blood pressure was normal For a year the mass gradually increased in size Thoracic aortography disclosed an aneurysm arising from the proximal part of the descending thoracic aorta partially filled with contrast medium (Fig 1) The lumen and contour of the descending thoracic aorta was irregular The patient died a month after the removal by operation of the aneurysm which had ruptured into the dorsal segment of the left lung Autopsy revealed



a b

Fig. 2. Case 2. a) Two masses of smooth contour protruding from the superior mediastinum into the upper part of the left lung. b) Contrast injection into the right atrium. Two aneurysms arising from the distal part of aortic arch; the aorta is narrowed in the vicinity of the aneurysm. Aneurysmal dilatation of the right subclavian artery.

arteritis mainly involving the media and adventitia in the remaining parts of the aorta and the renal arteries.

Case 2. Female, aged 20, who at the age of 13 years developed a mediastinal mass and a slight temperature. The mass gradually increased in size and the patient had severe pain radiating from the left anterior thoracic wall to the back. A systolic murmur was evident along the left sternal border. Conventional films of the chest disclosed masses with sharp outlines protruding from the superior mediastinum into the upper part of the left lung (Fig. 2a). Retrograde catheterization of the aorta failed and aortography was performed after venous injection. Two aneurysms arising from the distal part of the aortic arch were then demonstrated. The lumen of the aorta was narrowed in the vicinity of the origin of the aneurysm (Fig. 2b).

Case 3. Female, aged 24, complaining of palpitations, general malaise, loss of weight and weakness of the hands. The radial pulses were hardly palpable and the blood pressure could not be measured in the upper extremities; it was normal in the lower extremities. A systolic murmur was audible in the right supraclavicular fossa. A protrusion of the aortic arch was



Fig 3 Case 3 a) Dilatation of the aortic arch the descending aorta has a wavy contour b) Fusiform aneurysms of the aortic arch demonstrated by thoracic aortography Narrowing of the middle portion of the descending *aorta corresponding to* the wavy contour present in the conventional roentgenogram (a) Marked stenoses of the bilateral axillary arteries c) Fusiform aneurysm in the upper part of the abdominal aorta

seen at conventional roentgenography of the chest the descending thoracic aorta had a wavy contour (Fig 3a) Fusiform aneurysms of the aortic arch and the proximal part of the abdominal aorta were revealed by retrograde aortography (Fig 3 b and c) The middle part of the descending thoracic aorta was moderately narrowed and the brachiocephalic arteries were irregular in contour marked stenoses of the axillary arteries were evident bilaterally

Case 4 Female aged 22 with pulsations in the right supraclavicular fossa and a slight temperature cough palpitations and dyspnea Her appetite had decreased gradually A systolic murmur was present on admission in the first intercostal space close to the sternal bord r Conventional roentgenography of the chest disclosed bilateral enlargement of the superior mediastinum and the heart Thoracic aortography revealed marked aneurysmal dilatation extending from the ascending aorta to the proximal half of the descending thoracic aorta (Fig 4a) Two fusiform aneurysms were present in the upper part of the abdominal aorta (Fig 4b) A small amount of the contrast medium regurgitated into the *left ventricle*

Case 5 Female aged 33 with palpitations weakness of the extremities and edema of the face which started three months after child birth The blood pressure in the right arm was 170 80 no record from the left arm Conventional films of the chest revealed a protrusion



a b

Fig 4 Case 4 a) Huge fusiform aneurysm extending from the ascending aorta to the middle part of the descending aorta b) Successive fusiform aneurysms of the upper part of the abdominal aorta

of the aortic arch and dilatation of the heart There was decreased vascularity in the upper part of the right lung Thoracic aortography indicated obstruction of the left subclavian artery and an aneurysm of the left common carotid artery

Discussion

Stenoses or obstructions of the arterial system frequently revealed in this syndrome, are caused by intimal proliferation and thrombosis following an inflammatory process of the media and adventitia (NASU) Dilatation of the vessels has been thought rarely to be associated with this syndrome, however We have in earlier paper (KOZUKA et coll) reported upon dilatation of the ascending aorta The formation of aneurysmal dilatation is possibly due to the

degeneration and weakening of the media and accordingly it is natural that aneurysms are frequently found in the thoracic aorta and in the brachiocephalic arteries where stenoses are most common

Although this report indicates that a close relationship exists between the syndrome and aneurysms it is strange that so few cases of this kind have been reported perhaps because it has not been generally recognized that aneurysms may occur in this syndrome There must actually exist more cases of aneurysm in the aortitis syndrome

The shape and size of the aneurysms varied in the present series Fusiform aneurysms were dominant as compared with saccular aneurysms which were detected in only two cases It was interesting to find two fusiform aneurysms in the proximal part of the abdominal aorta both in Case 3 and Case 4

The aneurysm in Case 1 gradually increased in size and probably also in Case 2 such cases may demand sudden operative intervention Calcareous deposits in the involved aortic wall are not uncommon in this syndrome one of the features in the late or cicatricial stage as stated by GILLANDERS et coll The size of an aneurysm with calcification of the wall was in one case unchanged about a year later

Coarctation of the aorta which is less common in Japan than elsewhere may also be accompanied by aneurysm of the brachiocephalic arteries as well as of the aorta due to hypoplasia or defect of the media It is relatively easy to differentiate this condition from the aortitis syndrome by the great irregularity of the contour and thickening of the wall of the aorta in the latter condition

Other aneurysmal conditions may be distinguished roentgenologically by the presence of stenoses or obstructions of the aorta or its main branches as well as of the pulmonary arteries especially in young female subjects An arteriosclerotic aneurysm could sometimes be differentiated from the syndrome only with difficulty because of stenoses and irregularity of contour due to plaque formation in the aorta and its main tributaries The ages of the patients are of course important but are not always helpful Syphilitic aneurysms occur mainly in the ascending aorta in which however stenoses or obstructions in the arteries are infrequent

Pathologic studies of the etiologic factors support the view that this syndrome is an autoimmunizing process though the nature of the trigger mechanism and the reason for the dominance in young females are unknown

SUMMARY

Aneurysms of the aorta and sometimes also of the brachiocephalic arteries were demonstrated in seven out of sixty cases with the aortitis syndrome In this syndrome in which stenosis or obstruction of the arterial system are usually reported it would appear that aneurysms may often be formed

ZUSAMMENFASSUNG

In sieben von sechzig Fällen mit Aortitis Syndrom konnte das Auftreten von Aneurysma der Aorta und gelegentlich der brachiocephalen Arterien beobachtet werden. Es scheint dass dies Syndrom, das Stenose und Verschlüsse der Arterien hervorbringt, auch häufig Aneurysmabildungen mit sich bringt.

RÉSUMÉ

Des anévrismes de l'aorte et parfois aussi des artères brachiocéphaliques ont été mis en évidence dans 7 cas sur 60 cas de syndrome d'aortite. Il semble que des anévrismes peuvent se former dans ce syndrome où on constate habituellement des sténoses et des obstructions du système artériel.

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VENOUS ARTERIOGRAPHY

A modified technique and indications for its use

by

N E Ahlberg O Bartley and N Chidekel

A basic principle in angiography is that the contrast medium should be administered as close to the actual region as possible It follows that for examination of arteries the contrast medium should be selectively injected A precursor to the more selective investigation methods was the one in which the *injection* was made on the venous side in this report called venous arteriography The method was first used by Steinberg who together with Robb described it in 1939 (Robb & Steinberg)

An examination in detail of an artery depends on an adequate concentration of the contrast medium within it When the medium is injected on the venous side the concentration in the arteries is affected by many factors such as the site and rate of injection and the amount and concentration of the medium used Other important factors must also be considered however such as the method of puncture and its site as well as the circulation time through the lungs

Some authors have used direct injection through a needle in an arm vein (Steinberg et coll Viallet et coll Mathieu *et coll*) Others have employed

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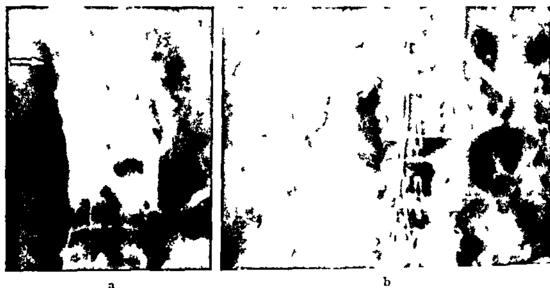


Fig. 1. Male aged 48. a) Ten seconds after start of injection: the contrast medium is still held in the vena cava because of a tumour thrombus from the right renal vein bulging into vena cava (→). b) About 20 seconds later. Low contrast medium concentration in the abdominal aorta and its branches; abundance of tumour vessels suggestive of hypernephroma.

catheterization after cutting down on a vein, usually in the arm (BERNSTEIN et coll., SUTTON et coll., RONDEROS et coll., ZERBI ORTIZ & WELDON, BURKHEAD et coll., SCATLIFF & GREENSPAN), while RONDEROS et coll. and SCHRAMEL et coll., for example, inserted a catheter via the femoral vein. The catheter has been introduced centrally, either into the superior or inferior vena cava, the right atrium or the pulmonary artery. Only a few investigators have employed the percutaneous catheter technique with insertion of the catheter to or into the right atrium. The amount of contrast medium employed varies from 50 to 100 ml and its concentration between 70 % and 90 %. The rate of injection depends on the length and internal diameter of the catheter, the injection pressure and the viscosity of the medium. Most of the investigators cited have used a pressure syringe which is necessary for rapid injections.

The majority of authors have employed venous arteriography for investigating the thoracic and abdominal aorta and in several instances even for studies of the pelvic arteries. A few, including STEINBERG, have moreover used the method for the investigation of the mediastinum and the pulmonary vessels (RONDEROS et coll., MATHIEU et coll.), the heart (MATHIEU et coll.) and the cerebral vessels (VIALLET et coll.).

Venous arteriography is thus well known and often used. We have employed a modified technique on special indications. The present report deals with our experiences since 1961.



Fig 2 Female aged 83 with an aortic aneurysm extending cranially to within 1 cm of the renal arteries (⟶)



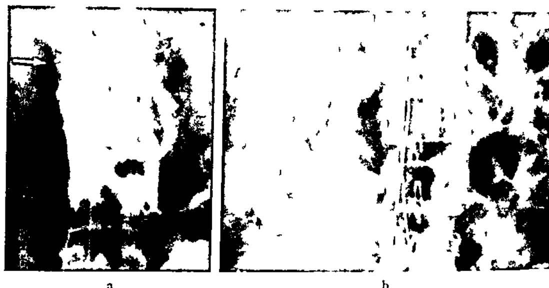
Fig 3 Female aged 67 with stenosis of the abdominal aorta above the renal arteries (⟶) and similar stenosis of the renal arteries (⟵⟶)

Methods Percutaneous puncture has been employed With few exceptions two polyethylene catheters (No 205) were inserted cranially into the inferior vena cava via the femoral veins on the two sides with the tips immediately caudal to the right atrium

The exceptions were patients in whom puncture of the femoral veins was contra indicated or for whom an examination of the superior vena cava was also required In these instances the arm veins were punctured percutaneously and the catheters inserted into them or via them into the superior vena cava About 100 ml Urografin 76 % equally divided between the two catheters were injected with a pressure syringe (Gidlund Elema) The injection pressure was 3 kg cm and serial films using an AOT changer (Elema-Schonander) were obtained in the a p projection The investigation was in some instances repeated with another projection this was necessary particularly when investigating the aortic arch and the arteries arising from it General anesthesia was not used The patients were premedicated with morphine scopolamine or promethazine chloride

Regardless of whether the contrast is injected on the venous or the arterial side the filled arteries are often projected over the skeletal structures and thus partially obscured in such cases the subtraction procedure has been used

Material and Indications The material consisted of 111 venous arteriographies carried out in 107 patients (52 men and 55 women) the average age of whom was 64 years (range 17—88 years) Some of the subjects were quite old and in



a b

Fig 1 Male aged 48 a) Ten seconds after start of injection the contrast medium is still held in the vena cava because of a tumour thrombus from the right renal vein bulging into vena cava (→) b) About 20 seconds later Low contrast medium concentration in the abdominal aorta and its branches abundance of tumour vessels suggestive of hypernephroma

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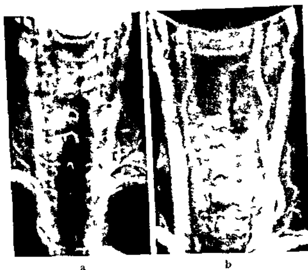


Fig 5 M le aged 71 w th calc fic t ons in th common a ot d artery the artery i markedly constricted par ticula ly on the left de below the bifurcat on a) A p projec t on b) Subtraction film of (a)

phroma (Fig 1) a renal cyst verified by direct puncture and complete occlusion of the left common iliac artery were diagnosed

Group (2) comprised 12 patients The film quality was satisfactory enough to answer the clinical question and in some instances to provide information about additional changes An aneurysm of the abdominal aorta was noted in seven patients while in the remaining five an aneurysm could be excluded All of the aortic aneurysms were situated caudal to the renal arteries and the relation between the aneurysms and the renal arteries could be judged (Fig 2) Renal artery stenosis (Fig 3) was observed in three of the patients in whom no aortic aneurysm was observed

Group (3) consisted of 48 patients in whom 52 investigations were made Adequate films were obtained in all the patients except one The exception was a 88 year old man with very slow passage of the contrast medium through the pulmonary vessels The pulmonary artery was still filled 20 seconds after start of the injection A repeat investigation was contra indicated since the patient had had a myocardial infarction only three weeks earlier No changes were observed in 15 of the 51 other investigations (Fig 4 a and b) Arterial stenosis due to atherosclerosis was a common pathologic finding (Figs 4c and 5) but in two patients (young women) it was probably due to so-called Takayashu s disease An



Fig. 4. Female, aged 58 (normal case). a) A.p. projection. b) Subtraction film of (a). c) Female, aged 77. No pulsation in the left radial artery: stenosis of the left subclavian artery (⟶) distal to the internal mammary artery; small atherosclerotic changes in the right subclavian artery.

poor general condition, with evidence of severe cardiac insufficiency. Despite this, no complications occurred.

There were four different indications for using the method: (1) technical reasons when arterial puncture with insertion of the catheter in the aorta was unsuccessful, (2) because of possible or verified aortic aneurysm, (3) for studying the aortic arch and the arteries arising from it, and (4) for investigation of the intrathoracic veins and the pulmonary arteries.

Results

Six patients came under category (1). They represented about 3 % of all the abdominal aortographic examinations carried out in the department from 1961 to 1963. Despite satisfactory bilateral puncture of the femoral arteries the insertion of the catheters failed because of the tortuous course of the pelvic arteries in five of these six patients. The exception was a patient with gastric carcinoma and probable liver metastases. Arterial puncture was not performed because there were no palpable pulsations in either groin. The concentration of the contrast medium was too low to permit of a detailed examination of the hepatic vessels. In five patients, the films were satisfactory. Among these patients, a hyperne



Fig 5 Male aged 71 with calcifications in the common c otid arte y the artery is markedly constricted par ticul ly on the left side below the bifurcation a) A p projec tion b) Subtr ct on film of (a)

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Fig. 6. Female, aged 76. a) Film of lungs. Mass in the apical part of the right lung close to the mediastinum. b) Venous arteriography. (The process was caused by aneurysmal widening of the brachiocephalic trunk.)

arterial aneurysm was apparent in two instances (Fig. 6). Additional information was obtained with the subtraction procedure in ten patients.

Group (4) comprised 41 patients and the same number of examinations. Pulmonary embolism seemed probable in twenty-two patients. Nine of them had changes typical of embolism; in nine other patients no such changes were observed. No definite diagnosis could be established in the remaining four patients.

The examination was performed for possible tumours in the lungs or mediastinum in 19 patients, the majority of whom had changes of the hilar region. Despite mediastinal tomography it could not be ascertained whether enlarged hilar lymph glands or widened pulmonary vessels were present. This could however be assessed angiographically in all these patients. An arteriovenous aneurysm was noted in one patient (Fig. 7). In another patient, with a probable bronchogenic carcinoma (Fig. 8), a growth extending into the superior vena cava and the left subclavian vein, as well as an occlusion of a pulmonary artery branch corresponding to the tumour were demonstrated. The diagnosis of carcinoma with metastases was verified at autopsy in the latter case.

Discussion

A detailed analysis of arteries requires a high concentration of contrast medium in them. This is best achieved with selective arteriography, which should usually be applied. However, to judge from the literature venous arteriography is widely used though only exceptionally under optimal conditions (RONDEROS



Fig 7 V nous arte ography i a male aged 39 with a mass n lower lobe of left lung Arterio enous aneurysm w th widened supply and drainage vessels

et coll ZERBI ORTIZ et coll FRIEDENBERG et coll BURKHEAD et coll SCATLIFF & GREENSPAN) The choice of method should among other things depend on the individual to be examined and the risks entailed with the method LANG reported a mortality of 0 06 % on arteriography carried out from the arterial side with Seldinger s technique while the corresponding figure at venous arteriography has been given as 0 02 % (STEINBERG) LANG has pointed out that the investigation of small arteries for example the brachial arteries increases the risk of complications

Insertion of a catheter through an aneurysm might lead to perforation of the wall or to emboli since aneurysms are often thin walled and as a rule contain an abundance of thrombotic material As in cases when catheter insertion via the femoral artery fails the arterial puncture may be performed at another site for example in the arm or neck arteries and the catheter can be introduced into the aorta The aorta may also be punctured directly We have however found that the frequency of complications is higher for both of these methods than for venous

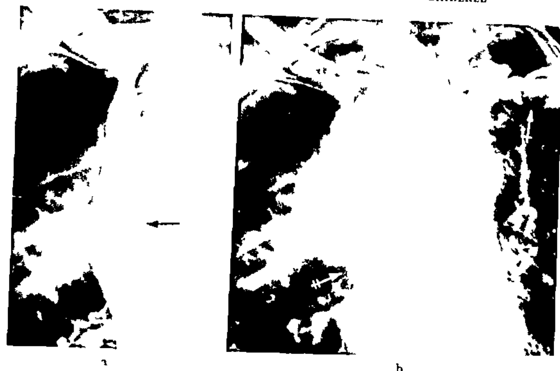


Fig 8 Female aged 51 with bronchogenic carcinoma Catheters inserted into arm veins four seconds between (a) and (b) The growth extends into the superior vena cava (⟶) metastasis at left subclavian vein (→→) occlusion of a pulmonary branch (↦⟶) corresponding to tumour

arteriography In these two categories, venous arteriography gave satisfactory information in the majority of patients so that no complementary study was required The hepatic vessels and the smaller branches of the renal artery could however not be studied in detail

For an examination of the aortic arch, insertion of the catheter from the arterial side in young subjects should be connected with only slight risks of complications Older patients usually have atherosclerotic changes in the aorta however, and the loosening of thrombotic material with circulating emboli, or production of a dissecting aneurysm, may become real risks In the present material the concentration of the contrast medium has been sufficiently high to allow a detailed examination but in some instances it has been necessary to employ the subtraction procedure

The selective method is clearly superior to venous arteriography for an investigation of the pulmonary arteries If the patient s condition permits and resources for selective catheterization of the pulmonary artery are available this procedure should be applied Selective catheterization was judged inadvisable in a large number of patients because of age or a poor general condition It

seems to us that in such cases angiography without selective insertion into the pulmonary artery should be favoured. Lung emboli among other manifestations were demonstrated with this method in a number of patients. When the differential diagnosis between hilar lymphoma and wide pulmonary vessels is dubious we hold that venous arteriography is usually adequate for solving the problem.

Risk of damage due to large volumes of highly concentrated contrast medium might exist. A detailed analysis of the renal function before and after investigations with contrast medium injections have however disclosed no changes to indicate renal damage (BARTLEY et coll.).

SUMMARY

A modified technique for venous arteriography is described and experience in 111 investigations presented. The method appears to be a valuable alternative to arteriography when catheterization of the abdominal aorta cannot be performed and further in cases of possible aneurysm of the aorta, for investigating the aortic arch and the large vessels arising from it and for analysing the intrathoracic veins and pulmonary arteries.

ZUSAMMENFASSUNG

Eine Modifikation der venösen Arteriographie wird angegeben und die Erfahrungen bei 111 Untersuchungen werden beschrieben. Die Methode erbietet eine wertvolle Alternative zur Arteriographie in Fällen, wo die direkte Arteriographie durch Katheterisierung der Bauchaorta nicht möglich ist, in Fällen von abdominalem Aneurysma und weiter für die Untersuchung des Aortabogens und der dort entspringenden Arterien, der intrathorakalen Arterien und der Pulmonalarterien.

RÉSUMÉ

Les auteurs décrivent une modification de la technique de l'artériographie par voie veineuse et en présentent l'application dans 111 cas. Cette méthode est utile pour remplacer l'artériographie quand il est impossible de cathétériser l'aorte abdominale, quand il peut y avoir un anévrisme de l'aorte, pour examiner la crosse de l'aorte et les gros vaisseaux qui en partent et pour étudier les veines intrathoraciques et les artères pulmonaires.

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FROM THE NEURORADIOLOGIC DEPARTMENT (DIRECTOR PROF T GREITZ)
KAROLINSKA SJUKHUSET STOCKHOLM SWEDEN

NORMAL CEREBRAL CIRCULATION TIME AS DETERMINED BY CAROTID ANGIOGRAPHY WITH SODIUM AND METHYLGLUCAMINE DIATRIZOATE (UROGRAFIN)

by

T GREITZ

Cerebral angiography has been used increasingly for investigations of the brain circulation and new contrast media with very limited influence on the local and systemic circulation have been developed One of these media is Urografin which has been found to be comparatively inactive with regard to cardiovascular reactions (TORNELL 1963 FISHER & CORNELL 1965 GREITZ & TORNELL 1967) It has recently been demonstrated that the bradycardia provoked by this medium does not significantly influence the result of a determination of the circulation time (GREITZ & SIK) We therefore decided to study the circulation time by means of Urografin which since 1957 has been used routinely in our institutions for cerebral angiography in about 7 000 patients

Material and Methods Forty four out of about 1 500 patients with normal findings at carotid angiography were selected All these had suffered from epilepsy or headache the findings on neurologic examination had been normal and all had been examined by rapid serial angiography (RSA) at either Serafimerlasa

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Table 2

*Comparison of the different measurements of the normal cerebral circulation time — Significance levels *** highly significant 0 001 > p ** significant 0 01 > p > 0 001 * almost significant 0 05 > p 0 01*

Variables	Correlation coefficients	
	Angiography of common carotid	Angiography of internal carotid
CT p CT c	0 891**	0 606
CT pa CT af	0 569	0 433
CT pa CT e	0 23	0 184
CT pa CT a	0 41	0 269

Results and Discussion

The results are given in Tables 1 2 and 3 The normal mean circulation time estimated as the time interval between maximum filling of the carotid siphon and maximum filling of the parietal veins (CT pa) was found with Urografin 60 % to be 3 43 ± 0 51 sec with a standard error of 0 08 sec (Table 1) This is a shorter time and a smaller standard deviation than established in previous studies (GREITZ 1956 LEEDS & TAVERAS 1963) in which sodium acetrizoate (Triurol) and sodium diatrizoate (Hypaque) were used the normal values then being 4 13 ± 0 78 sec and respectively 4 37 ± 0 83 sec There are several possible explanations for this discrepancy The shorter circulation time with Urografin could be due to a difference in activity as this medium is less active than the others The larger deviaton from the mean value however can hardly be explained in this way since the variation within the patient does not seem to be smaller with Urografin than with Triurol (GREITZ & SIK) The most plausible explanation is the more careful selection of patients for the present study As mentioned all patients with any neurologic signs were excluded The mean age of the present group of patients was 33 years in contrast to 40 years in the Triurol group There was however no definite correlation between circulation time and age in either group of patients

The time interval between maximum concentration in arteries and parietal veins (CT pa) has been shown to correlate well with the circulation time measured with radioactive isotopes (GREITZ 1956) In this study CT pa also correlated well with CT ce defined as the time difference between maximum concentration in the carotid siphon and in the internal cerebral vein However much weaker correlations were found between CT pa and CT af CT ae and CT a as defined above (Table 2) This could mean that these variables are not

Table 1

Normal cerebral circulation times as estimated in five different manners: as circulation time between the carotid siphon and, respectively, the parietal veins (CT pa) and the central veins (CT c), as the duration of the arterial filling phase (CT af), the arterial emptying phase (CT ae) and the arterial phase (CT a)

	CT pa	CT c	CT af	CT ae	CT a
Mean	3.43	3.48	1.67	0.91	2.52
Range	2.5–4.5	2.5–4.5	1.0–2.5	0.[illegible]–1.[illegible]	2.0–3.5
S.D.	0.51	0.51	0.45	0.29	0.45
S.E.	0.08	0.08	0.07	0.05	0.07

rettet or the Neuroradiologic Department of Karolinska Sjukhuset. Only patients meeting these three criteria were included and these also formed part of a group studied for determination of the normal size of the internal carotid, anterior and middle cerebral arteries (GABRIELSEN & GREITZ). Measurements of the diameters of these vessels were therefore available. In 16 patients, the injections had been performed automatically and ECG and injection times had been recorded. No ECG or exposures were on record for the remaining 28 patients, but these patients could be included in the present study since the cardiovascular reactions produced by Urografin are so slight that they have no demonstrable systematic effect on the circulation time. The accuracy of the program was moreover checked on several occasions, and no deviations exceeding 5 % were accepted.

Following percutaneous puncture of the carotid artery, each patient received 5 ml Urografin 60 % per injection. The injection time, when registered, was usually one second, or slightly more. Rapid serial angiography was always employed, with a fixed program of film changing: 2 films/second for five seconds and 1 film/second for ten seconds. The circulation time was estimated by the method of GREITZ (1956), as the time interval between maximum filling in the carotid siphon and maximum filling in the parietal veins (CT pa). A determination of the time lag between maximum density in the siphon and maximum filling of the internal cerebral vein (CT ce) was also made. The arterial filling time (CT af) is commonly used in routine work as an estimate of the circulation time and was also measured in this study. In addition, the time required for the emptying of all cerebral arteries (CT ae) was recorded. Finally, the time of arterial filling, from its commencement until all arteries were empty (CT a), as used by many others, e.g. LEEDS & TAVERAS (1963), was also measured. The results obtained from the determination of these several parameters of the circulation time were correlated with each other.

volume capacity better than any other single intracranial vascular measurement No correlation was found between C 5 and CT pa It was found that a correlation significant at the 1 % level existed between the diameter of the extradural portion of the carotid artery (C 5) and the circulation time estimated as arterial filling time (CT af) This was however only true when the injection was made into the internal carotid artery no such correlation was found for angiography of the common carotid artery The regression coefficient was 0 397 for the internal carotid and —0 211 for the common carotid artery the difference being significant at the 1 % level No significant correlation to arterial size for CT pa could obtained

Acknowledgements

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SUMMARY

Th cerebral circulation time was estimated at carotid angiography in a normal material *with* Urografin 60 % It was defined as the time interval between maximum filling of the carotid siphon and the parietal veins and was found to be 3 43 ± 0 51 seconds When the *injection was made into* the internal arotid artery the results obtained from estimates of the *t me of* arterial *filling* were d pendent on the size of the injected vessel and therefore invalid

ZUSAMMENFASSUNG

Di Plutumlauf*zeit im* Gehirn wurde mittels Carotisangiographie mit Urografin 60 % a n normal n Fall n ermittelt Die *Defini ion* der Umlaufzeit war der Zeitintervall zwischen d r Maximalfullun d s *Caroti iphons* und d r Parietalvenen gewohnlich 3 4 ± 0 51 sec Wenn die Injektion in die A carotis *interna erfolgte* wurden die Resultate die aus der Schatzung d r Fullungszeit d r arteriell *n Phase* erhalten wurd n von d r Weite dieses G fas s abhan ig und deshalb unbrauchbar

RÉSUMÉ

L t mp d circulation *cerebrale a* ete estime par angiographi carotidienne au moyen de l Urografin à 60 % sur un *ser e* normal Il a ete defini comme l intervalle de temps entre le remplissage maximal du *siphon* carotidien et celui des veines parietales et a ete trouve egal a 3 43 ± 0 51 secondes Quand l injection est faite dans l artere carotide in t rn les resultats indiquant le temps du *remplissage* d la phase arterielle depend nt du calib d vaisseau et ne sont donc pas valables

Table 3

Influence of the injection site on the measurement values obtained for the mean cerebral circulation times

Vessel injected	Number of cases	Mean circulation times				
		CT pa	CT c	CT af	CT ae	CT a
Internal carotid	27	3.37	3.48	1.54	0.96	2.48
Common carotid	17	3.54	3.50	1.88	0.8[illegible]	2.59
Test for difference		1.45	0.07	5.65	2.49	0.61

F values on 1 and 42 d.o.f.

so closely related to the velocity of the brain circulation. The site of puncture and the capacity of the injected vessel are factors that could affect these correlations.

In order to study the importance of the site of puncture for the circulation time the material was divided in two groups, one (27 patients) including those examined after puncture of the internal carotid artery, and one (17 patients) consisting of those in whom a puncture of the common carotid artery had been made. The mean circulation time, estimated as CT pa, CT ce, CT af, CT ae and CT a was calculated for each group (Table 3). A significant difference between the two groups was found only for CT af. This means that with the arterial filling time as an indication of circulation time the results will be dependent upon the site of puncture in that the circulation times estimated from injection into the internal carotid artery will be shorter than after injection into the common carotid artery. A possible explanation for this could be the fact that the contrast medium is transported mainly by the injection pressure during the injection interval and that this filling is more rapid than transportation by the blood stream. Furthermore, with injection into the internal carotid artery, the total volume capacity of the arteries distal to the puncture is smaller and hence they fill more rapidly than upon injection into the common carotid artery. A more distal injection into the internal carotid will consequently lead to a more rapid filling of the peripheral arteries and make the circulation appear to be more rapid.

To elucidate the role played by the capacity of the injected artery, the values of the circulation time, estimated as CT pa and CT af were correlated to the arterial size. The diameter of the extradural parasellar portion of the internal carotid artery was measured on the lateral film. The measurements were taken precisely at the first bend of the artery shortly after its exit from the carotid canal. The diameter at this level (C 5) is fairly representative of the width of the entire main trunk of the internal carotid artery and is likely to reflect the

FROM THE ROENTGEN DEPARTMENT (DIRECTOR OLIVER AXEN) OF THE GENERAL HOSPITAL JONKOPING SWEDEN

BRACHIAL VERTEBRAL ANGIOGRAPHY WITHOUT A CATHETER

by

BENGT ZACHRISSON

Vertebral angiography by retrograde injection of contrast medium into the brachial artery was first described in 1955 by GOULD who exposed the brachial artery and injected the contrast medium manually The method was considered especially suitable for children as the infratentorial vessels were well filled but in adults large amounts of contrast medium were needed to produce satisfactory films COLLINS in 1957 reported however that he had obtained good results in adults by applying Gould s technique and using large cannulas KUHN (1960) reviewed 200 cases in which injection of contrast medium into the right brachial artery had been performed after exposure of the vessel No serious complications had occurred He recommended right side injection as a routine method to replace right percutaneous carotid and vertebral puncture CARREA & SCHUSTER (1961) used the same method in 100 aortographies in children The injection was usually made on the left side and in most cases the cerebral arteries as well were well demonstrated There were no complications and no ischemia despite the fact that the radial pulse disappeared permanently in a few instances

Excellent results with percutaneous puncture of the brachial artery in combination with injection of the contrast medium with a pressure injector have been reported since 1960 both from Germany and from America

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a b c

Fig 2) Sub lav artery and its bra ches after nj ct on of contrast m dium into the left brachial a t y The ert bral tery i con tri ted at t ex t f om the subclav an a tery b) Drawing (afte R LBER KOP CH) how g the po tion of th bra hial artery n relation to ne vus med anus c) P nctu e s t

fascia The fact that the artery is superficially situated at this level and hence that the angle of insertion of the needle will be small is an added advantage After local anesthesia has been produced with about 5 ml xylocain 1 % both vessel walls are punctured The mandrin is withdrawn and the needle is then pulled back slowly A release from the posterior wall and a strongly pulsating stream indicate that the needle is in a satisfactory position

A short wire guide projecting a few centimeters beyond the needle tip is introduced and the needle is cautiously pushed into the artery this ensures that the needle will remain steady Its position is further checked by taking a film during the injection of about 3 ml Urografin 60 % if the tip is seen to be in contact with the vessel wall its position is adjusted The needle is connected with a PE tube coupled to a pressure injector (Cical) To prevent the contrast medium from passing to the arm and hand and to counteract pain a cuff inflated to a level higher than the systolic pressure is applied proximally on the forearm

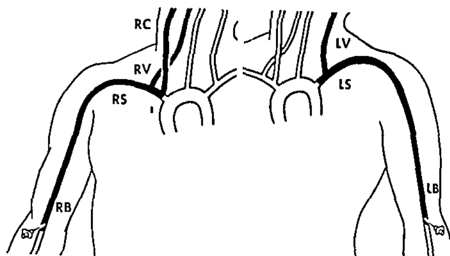


Fig. 1. Schematic drawing showing contrast filling after retrograde injection into the right brachial artery (left part of diagram) and into the left brachial artery (right part).

MARSHALL et coll. (1963) discussed exhaustively the advantages of the percutaneous method, describing 175 cases, in only four of which it had been necessary to use surgical exposure. No serious complications were noted.

WALLENSCHMIDT (1965, 1966) reviewed more than 200 cases in which retrograde brachial arteriography had been carried out without serious sequelae. The infratentorial vessels were demonstrated by left side injection in more than 90 % of the examinations, while by right side injection the supratentorial vessels on the right side were filled in nine out of 10 cases and the infratentorial vessels as well in eight out of 10 cases. He used in adults a PE 205 cannula, 40 ml Urografin 60 %, and an injection pressure of 2 to 4 kg/cm². WENDE employed a cannula of the same size but injected 25 to 30 ml Urografin 60 % at a pressure of between 6 and 7 kg/cm².

The method used at our hospital is a modification of methods recommended by WALLENSCHMIDT and WENDE.

Technique. The brachial artery is punctured with a PE 160 Seldinger needle at the site where the pulsations are best felt: this is usually at the ulnar side of the elbow joint, where the artery lies under the bicipital fascia. This region has several advantages. The large number of collaterals at the elbow joint constitute a safety margin in the event of thrombus formation, and furthermore the median nerve lies slightly medial to the artery at this level while higher up on the upper arm it hugs the artery closely (cf. Fig. 2b). The risk of injury to the nerve will consequently be less if the puncture is performed at the level of the bicipital



F g ? a) S bcl ian a t y a d its b anches aft r inject on f cont t med um into the left brachial artery Th v teb al artery s nstricted at ts exit from th subcl ian artery b) Drawing (afte RAUBER KOPSCH) how ng the p s t on of the brachial artery in relat on to nervus median s Pun tu e te

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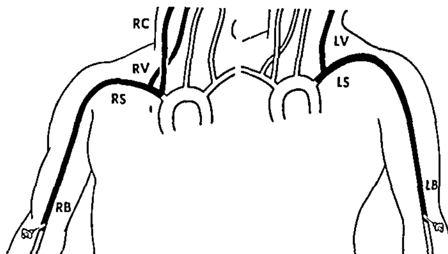


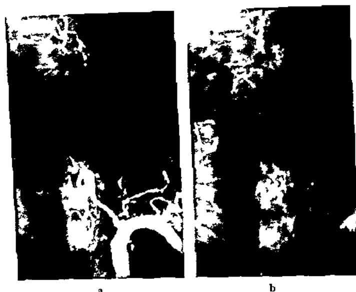
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a b

Fig 3 Cervical port on of the verteb al artery sec (a) a d 4 5 sec (b) fter st rt of nject on The vertebral artery s largely occluded a d has be n part ally fill d th ough collater ls Accumulation of contrast medium i the left lobe of the thyroid gland seen in (b)

cating artery by the carotid artery on the same side (SALTZMAN 1959) When the carotid artery in the neck is compressed the flow through the posterior com municating artery diminishes while that from the vertebral basilar system to the posterior cerebral artery increases (Fig 4) In four patients only partial filling of the right posterior cerebral artery was achieved another injection of contrast medium together with compression of the right carotid artery, gave satisfactory filling in three of these patients while in the fourth it remained partial In two the ip ilateral posterior communicating artery was also demonstrated

The posterior cerebral artery sometimes arises directly from the carotid siphon and does not communicate with the basilar artery In such cases it cannot be demon trated by vertebral angiography

An examination using compression of the right vertebral artery was tried in four patients the compression being low down in the neck in the supra clavicular fossa Without compression no filling of the right vertebral or the right posterior inferior cerebellar artery was obtained in these patients With compression however satisfactory filling of the right posterior inferior cerebellar and the right vertebral artery close to the base of the skull was obtained in three

Urografin 60 % in an amount of 35 to 40 ml is injected at a pressure of 6.5 to 7 kg/cm². Films are obtained in the lateral projection (3 per sec for 4 sec, and then 1.5 per sec for 4 sec) and in the frontal projection (2 per sec for 6 sec, then one per sec for 6 sec). The left vertebral artery usually becomes visible in the neck after 0.25 to 1.5 sec. The injection time is around 3 sec. As a rule, two to three injections of contrast medium are made at each examination. Four injections of each time were made in a few cases.

The left subclavian artery gives off only one artery to the brain, the left vertebral artery. The right subclavian artery gives rise to both the right vertebral and the right common carotid artery. If contrast medium in sufficient quantities is injected into the brachial artery in a retrograde direction, and at sufficiently high pressure, a column of contrast medium extending in a proximal direction as far as the aortic arch will be obtained, and all the branches springing from the subclavian artery, including the vertebral artery, will become visible.

Injection of contrast medium on the left side thus gives intracranially a selective left vertebral angiogram (Fig. 1b). Injection on the right side allows simultaneous angiography of the right vertebral artery and the right common carotid artery (Fig. 1a).

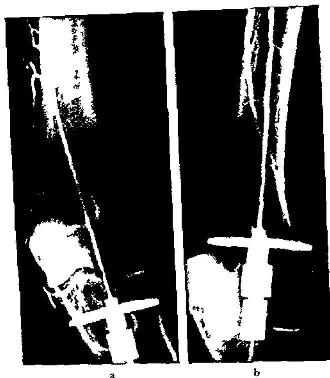
The left vertebral artery is said to arise directly from the arch of the aorta immediately proximal to the origin of the left subclavian artery, in approximately 6 to 7 % of cases (Bosniak 1964, Sutton & Davies 1966). In such cases contrast filling of the vertebral artery via the left arm is for anatomical reasons not possible with this technique. Some other method, for instance direct puncture in the neck, must be used instead.

Results

Thirty five patients of ages ranging from 20 to 74 years were examined between August 1965 and August 1966. In a further patient, puncture of the brachial artery was unsuccessful. Contrast filling allowing evaluation of the infratentorial vessels was achieved in 31 of the 35 patients. In one of the remaining four, the vertebral artery in the cervical region was highly tortuous and variable in caliber and the infratentorial vessels were only partially outlined; in two others the vertebral artery was occluded (Fig. 3) and in the fourth case it arose from the aortic arch.

The filling of the vessels was classified as satisfactory if their outlines and peripheral ramifications were distinguishable, as partial if only parts of the course were demonstrated, or as absent. A few examinations using compression were carried out in an endeavour to improve the contrast filling.

The posterior cerebral artery is also supplied through the posterior commun-



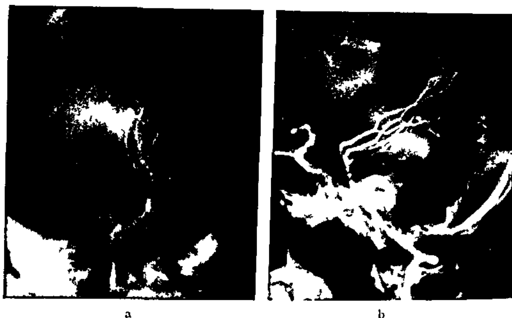
F g 6 a) Spasm of the b ach l art ry near the needle tip Co lla teral are cont a t filled b) H gh divis on of the brachial artery The needle fills th ent re lumen no collaterals are vis ble

of them while in the fourth the vertebral artery failed to fill on the right side (Fig 5)

Complications The radial pulse was recorded immediately before and after the examination Twenty four patients were followed up and a further six gave in formation by telephone No serious sequelae occurred and no ischemia was observed after the examination

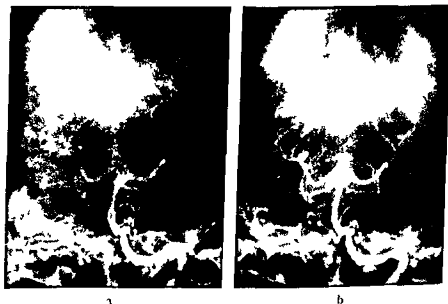
In one patient with moderate hemiparesis due to constriction of the right internal carotid artery the condition became temporarily aggravated after the examination No compression in the neck had been applied in this case

The radial pulse was feeble in one patient after the examination but was normal again the following day Spasm of the brachial artery manifested by disappearance of the radial pulse arose in two patients during the examination Fig 6a) but relaxed after the application of hot compresses In one of these pa



a b

Fig. 4. a) Frontal projection. Only branches of the vertebral artery on the left side are filled. b) Lateral projection with simultaneous compression of the right carotid artery. Satisfactory filling of the vertebral artery and its branches including the right posterior cerebral artery and right posterior communicating artery.



a b

Fig. 5. Left side injection into the brachial artery. a) Without compression the basilar artery and the right posterior cerebral artery are partially filled. b) With compression in the right supraclavicular fossa all branches of the vertebral artery including the right posterior inferior cerebellar artery with adjoining portions of the right vertebral artery are filled.

ever if correctly performed this method allows excellent demonstration of the vertebral artery and its branches

Various catheterization techniques have also been suggested for the demonstration of the vertebral artery The catheterization may be performed through the femoral artery (LINDGREN 1956) or through the axillary artery with a catheter placed in the left subclavian or vertebral artery (RADNER 1951) Good results may be obtained but the procedure is usually time consuming as it is necessary to get exact information while positioning the catheter preferably by TV monitoring Protracted catheterization furthermore increases the risk of complications at the puncture site in the form of thrombosis or hematomas A few deaths in connection with catheterization of the vertebral artery have been reported

Retrograde injection of contrast medium into the brachial artery has proved an excellent method for vertebral angiography Satisfactory roentgenograms were obtained in 34 of the 35 patients examined The method has also been recommended by German and American investigators who have all stressed the high rate of successful examinations and the absence of serious complications

It was possible by applying compression to demonstrate the right posterior inferior cerebellar artery in three out of four patients Compression of the carotid artery can be carried out and in some cases gives better filling of the ipsilateral posterior cerebral artery

Amounts of 30 to 40 ml Urografin 60 % were used 40 ml gives slightly better and more evenly distributed contrast filling of the infratentorial vessels It is difficult to determine how much of the contrast medium actually passes up into the vertebral artery However the arterial capillary and venous phases were always clearly distinguishable an observation indicating that the intracranial dose of contrast medium was adequate

The discomfort of the patient on injection of contrast medium into the brachial artery may be slightly greater than with direct injection into the vertebral artery but it soon passes off The fact that the left vertebral artery arises from the arch of the aorta in about *6 to 7* % of all cases is another disadvantage of the method since no demonstration of the vertebral artery is then possible The procedure is furthermore slightly more time consuming than a direct puncture in the neck

The method has many advantages however It is usually easy to puncture the brachial artery The position of the needle can be kept stable and can be observed and adjusted as required The position of the patient's head can be altered to meet requirements without affecting the position of the needle Compression of the neck arteries can easily be carried out and the cervical part of the vertebral artery as well as the subclavian artery and its branches can be well and rapidly outlined by contrast medium No serious sequelae have occurred



Fig. 7. a) Frontal projection 4 sec after start of injection. b) Axial projection 3 1/3 sec after start of injection of contrast medium in a man aged 51 years with a highly tortuous and dilated basilar artery.

tients the radial pulse was feeble for the first few hours but returned to normal within twenty-four hours. In the other, there had been difficulty in puncturing because of high division of the brachial artery, the needle completely filling the lumen of the artery at that point; the radial pulse was feeble during the first week but subsequently returned to normal (Fig. 6b). Thus, in the whole series temporary weakening of the radial pulse was noted in only three cases.

One patient experienced aching pain around the puncture site and stiffness of the fingers during the first week but later had no further discomfort. In this particular instance the brachial artery had been punctured at a point about 7 cm above the elbow point and irritation of the median nerve may have arisen.

Extravasal injection of some of the contract medium occurred in one patient. The radial pulse was not affected and the patient complained of no discomfort when he left the examination room.

Discussion

Percutaneous puncture of the vertebral artery in the neck (LINDGREN 1950, SJÖGREN 1953) is the most common technique in Sweden for vertebral angiography. The method requires highly trained, efficient operators, however, as technical difficulties often arise during puncturing. Failures may be due to difficulty in placing the needle adequately. If the puncture is not carried out in the correct way, complications such as puncture of the dural sac, injury to the nerve plexus, or arteriovenous shunt formation at the puncture site may arise. How-

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SUMMARY

Vertebral angiography with retrograde injection of the contrast medium into the left brachial artery gave good results in 34 of the 35 patients examined. The only exception was a patient in whom the vertebral artery arose from the arch of the aorta. Compression of one of the carotid arteries or of the right vertebral artery may often be of value. No serious complications have been observed.

ZUSAMMENFASSUNG

Gute Resultate wurden in 34 von 35 Fällen erzielt, wenn Vertebralisangiographie durch retrograde Injektion in die linke A. brachialis vorgenommen wurde. Die einzige Ausnahme war ein Fall, in dem die A. vertebralis direkt vom Aortabogen entsprang. Kompression einer der Aa. carotis oder der rechten A. vertebralis kann oft von Wert sein. Keine ernsten Komplikationen sind beobachtet worden.

RÉSUMÉ

L'angiographie vertébrale par injection rétrograde de moyen de contraste dans l'artère humérale gauche a donné des résultats utilisables dans 34 cas sur 35. La seule exception a été un cas où l'artère vertébrale partait de la crosse de l'aorte. La compression d'une des artères carotides ou de l'artère vertébrale droite améliore souvent le résultat. L'auteur n'a pas observé de complication grave.

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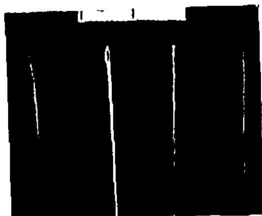


Fig 1 Arterial needle 1 0 mm outer diameter and 0 6 mm inner diameter Guide wires with diameters of re pec tively 0 9 mm and 0 6 mm PE 160 ant catheter

The puncture of an artery must be non traumatic i e any permanent consequences of the procedure must be avoided There is for instance little danger in twice puncturing the femoral artery of an adult with a 1 6 mm needle and introducing two catheters during one examination On the other hand a single puncture with such a needle into the femoral artery of a 6 year old child or into the brachial artery of an adult may produce prolonged bleeding spasm arterial thrombo is and even permanent occlusion

After the artery has been punctured without trauma using a needle of as small an outer diameter as possible the percutaneous catheterization of medium and small sized bloo l vessel should if necessary be possible to perform also with the aid of the standard equipment consisting of 0 9 mm guide wires and ordinary catheters with a tip of 0 9 mm innner diameter

These requirements may be fulfilled by the following technique which we have used for more than a year Up to the present the youngest child subjected to femoral artery catheterization was 13 months old (Fig 3a)

We use (see equipment shown in Fig 2) a needle with a corrugated hub-shield of 1 0 mm outer diameter and a little over 0 6 mm inner diameter having a length from tip to hub of 50 mm It has a short sharp-pointed bevel and female Luer Lok A close fitting obturator of 0 6 mm outer diameter with a rounded end extends over the tip of the needle for about 2 5 mm and is freely moveable The needle was specially designed with minimum diameters for easy and safe arterial puncture The puncture may also be performed with a Jensen Buchtala needle (outer diameter 1 0 mm inner diameter 0 6 mm) or with the inner cannula of a three piece PF Seldinger needle The lumen of the latter will accept a 0 6 mm guide wire We have not found this cannula very satisfactory however

FROM THE RADIOLOGIC CLINIC (DIRECTOR PROF. H. J. KOLLING) MARTIN LUTHER UNIVERSITY, HALLE, GERMANY

NONTRAUMATIC PERCUTANEOUS CATHETERIZATION OF BLOOD VESSELS WITH GUIDE WIRES

by

CHRISTA BECKER and HANS W. BECKER

The puncture of an artery or vein, and the introduction of a guide wire and catheter in human subjects was described by SELDINGER (1953). This procedure, with needle catheter replacement in cardiovascular roentgenology constitutes a safe and realiable method of high diagnostic value.

The standard guide wire of 0.9 mm outer diameter requires a certain inner diameter and therefore also a certain outer diameter for the needle: this is usually 1.6 mm. Even a skilled examiner will obviously have difficulty in puncturing a child's artery for the insertion of a 0.9 mm wire, if the child is under a certain age and developmental stage. This was admitted by CASTELLANOS (1964) who states: "Percutaneous puncture of arteries is difficult in children and the examination must be performed as a rule after a cut down". The same opinion was expressed by VENGSARKAR et coll. (1963) and KAUFMANN et coll. (1953). The lowest age at which the 1.6 mm needle can be introduced into the femoral artery varies and can be 8, 10 or 12 years. We have found that in a normal child of 12 years the artery may always be punctured satisfactorily with a 1.6 mm needle, without any serious consequences, but not always at the age of 10 years. An absolute lower limit of 8 years is therefore suggested.

Submitted for publication 14 april 1967

care After the guide wire is secure and freely moveable in the vessel lumen the cannula is withdrawn Slight digital compression just upstream from the puncture site of the artery prevents bleeding One of two different procedures are now open to the operator

1 *The introduction of a PE 160 catheter or of an Ödman red injection catheter with a tip prepared to fit the 0 6 mm guide wire* Retrograde abdominal catheter aortography in smaller children is possible if a catheter length of not more than about 300 mm is sufficient The narrow (0 6 mm inner diameter) tip of the injection catheter permits a relatively minimal backflow of contrast medium whereas the side holes in an Ödman red catheter allow a certain semi selective filling of e g the renal arteries

2 *The use of a 0 9 mm standard guide wire and injection catheter with tip adapted to the 0.9 mm inner diameter* First a 100 mm (to 150 mm) PE 160 assistant catheter (Kifa, Stockholm Clay Adams New York) having a tip which has been adapted to the 0 6 mm guide wire is slipped over the wire into the artery (Fig 1 and 2)

The tip is best prepared by stretching it over 0 6 mm nylon or perlon wire (The tips of opaque catheters (type Ödman) are also usually prepared by threading them on a 0 9 mm nylon or perlon wire This procedure has two advantages the metal guide wires are spared and the heating apparently remains more localized) The essential point in the preparation of the tip of the PE 160 assistant catheter is that the tip defined here as the transition zone from an inner diameter of 0 9 mm to one of 0 6 mm should not be longer than 1 to 2 *mm*

The guide wire and the PE 160 assistant catheter are best slipped together into the artery rather than the catheter over the fixed guide The guide wire having been withdrawn the spurting of blood from the cock end of the catheter marks the correct positioning of the assistant catheter The catheter is rinsed and the cock closed

In children over 2 to 3 years of age an Ödman red dilatation catheter (length 100 to 150 mm) with the tip exactly adapted to the 0 6 mm guide wire and the end cut may be used with advantage (Fig 2) The dilatation catheter is slipped over the guide wire and the catheter tip introduced into the artery the catheter is then immediately changed for the PE 160 assistant catheter Damage to the fine tip of the latter in passing skin and subcutaneous tissue is thus avoided Three points must however be mentioned

1 When changing the dilatation catheter for the assistant catheter the rule for catheter changing is broken i e that a catheter be changed only for another of the same or of greater diameter therefore during the time the PE 160 assistant

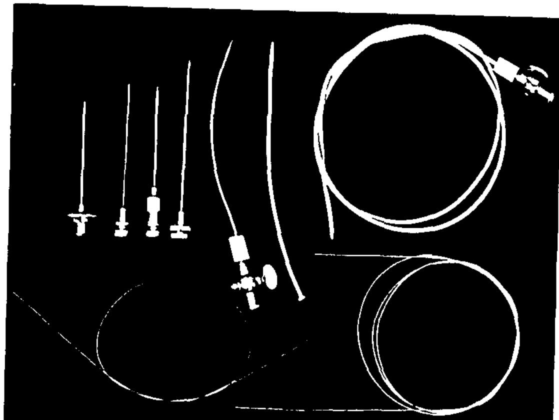


Fig. 2. Various equipment for catheterization. Small lancet for making a stab wound through the skin prior to vessel puncture. Male Luer Lok syringe for catheter rinsing. Special arterial needle, 1.0 mm outer diameter and 0.6[illegible] mm inner diameter, with hub shield and circular protruding obturator. Jensen Buchtala needle, 1.0 mm outer diameter. Inner cannula of Seldinger LL 160 needle. Guide wires with diameters of respectively 0.6 mm and 0.9 mm. PF 160 assistant catheter, length 100 mm, with a 1 mm to 2 mm long tip having a diameter of 0.6 mm. Ödman red dilatation catheter, length 100 mm, tip of 0.6 mm diameter. Injection catheter with tip of 0.9 mm inner diameter, length, curvatures and bends of the catheter being adapted to the actual examination to be performed.

A successful puncture of the artery is indicated by the characteristic pulsating flow of arterial blood. The flow in children will actually be more of a drip due to the lower arterial pressure in these subjects and the small lumen of the needle. The needle, with the obturator in position, is then passed a little further into the artery. The obturator is thereafter pulled back, and a flexible 0.6 mm guide wire is inserted. We use a guide wire which is 400 mm long; it has the form of a spiral made of 0.2 mm wire closely wound around a core wire also of 0.2 mm diameter (quality X 12, CrNi 17 7); the tip is flexible. The exact diameter of the guide wire is actually 0.63 mm, and it was specially designed by us to serve our purpose. Its length is at present limited only by technical factors of manufacture. Insertion of the guide wire into the artery must be performed with all necessary

by gentle pressure exerted by the end of the guide wire The successful under taking of this procedure depends on the exact and perfect preparation of the tip of the PE 160 catheter This phase of the procedure that is of dilating and passing the tip should be tested by means of a second identically prepared assistant catheter when checking the puncture and catheterization equipment which is always an essential part when preparing for an angiographic examination

The next step is to withdraw the assistant catheter, leaving the 0 9 mm guide wire in position and applying gentle digital pressure upstream from the puncture site The injection catheter with its 0 9 mm inner diameter tip is slipped over the wire and both are advanced along the artery If necessary in the course of angiography especially if selective catheters and guide wires of standard size (0 9 mm) may be changed in accordance with recognised principles and depending on the region to be reached

The method permits puncture and catheterization of the femoral artery even in young children (Fig 3) and if required of the brachial axillary and carotid arteries of children and adults The veins of the elbow axilla and inguinal region may also safely be punctured and catheterized percutaneously

Acknowledgement

The authors take this opportunity of thanking Mrs Inge Kochanowski and Mrs Zurhorst Meier for technical assistance

SUMMARY

The equipment and procedure for the safe percutaneous catheterization of arteries and veins with the outer diameter of the needle about the same size as the guide wire are described in detail The method is particularly suited for catheterization of the femoral artery in children and special vessel regions in adults

ZUSAMMENFASSUNG

Instrumentarium und Verfahren zur schonenden perkutanen Katheterisierung von Arterien und Venen wobei der Aussendurchmesser der Punktionsnadel in der Grossenordnung des konventionellen Fuhrungsdrahtes liegt werden beschrieben Die Methode ist fur Katheterisierung der A femoralis bei Kindern speziell geeignet als auch fur bestimmte Gefassgebiete bei Erwachsenen

RÉSUMÉ

Les auteurs decrivent en detail l instrumentation et la technique du catheterisme des arteres et des veines sans danger au moyen d une aiguille dont le diametre exterieur est a peu pres le meme que celui du fil guide Cette methode est utile pour le catheterisme de l artere femorale chez l enfant et pour certaines regions vasculaires de l adulte



Fig 3 a) Percutaneous retrograde catheter aortography in a 13 month old child Aplasia of right kidney hypertropy of left kidney b) Percutaneous catheterization of left subclavian artery via the femoral artery in a 8 year old child Occlusion of the brachial artery at the elbow after intercondylar fracture followed by ischemic contracture

catheter is indwelling slight manual compression of the artery upstream from the puncture site may occasionally become necessary

2 The dilatation catheter is therefore best not applied if the injection catheter itself is of the PE 160 type

3 If the dilatation catheter is used, the tip of the PE 160 catheter may be prepared in advance with an inner diameter of 0.8 or even 0.9 mm thereby facilitating the next step in the procedure

With the PE 160 assistant catheter in position the cock is open and the rigid end of a 0.9 mm guide wire is introduced This wire must be long enough to fit the injection catheter to be inserted later and the end of the wire must be smooth and rounded in short it must be in perfect condition The end of the wire is moved to the tip of the assistant catheter which is now dilated and advanced

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ROENTGEN EXAMINATION OF STRICTURE OF THE LOWER OESOPHAGUS

by

W Mortensson and S Sandmark

Oesophagoscopy and roentgenology are the methods of choice in the investigation of a stenosing lesion of the lower end of the oesophagus The endoscopic method allows inspection and biopsy but often only of that part of the oesophagus above the stricture Roentgen examination will outline the lumen of the oesophagus above the stricture give information on the length and the severity of the stricture as well as on the condition of the oesophagus below the lesion and thereby indicate the nature of the disease Diagnostic errors due to faulty roentgen technique are not uncommon This paper is concerned with a simple roentgen examination method allowing complete demonstration of a stenosing lesion of the lumen of the lower oesophagus

A heavy barium meal is usually used in the roentgen examination of the oesophagus The patient is examined standing or recumbent although attempts have been made to improve the diagnosis by examining the patient in the head down position or with the abdomen supported on a pillow or during increased

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a b

Fig 2 Examination with a heavy barium contrast medium and no abdominal compression Long stricture with ulceration collapsed hernia b) Light barium contrast medium and abdominal compression Hernia and a short stricture

Case reports

Case 1 A woman aged 74 had for some months had increasing swallowing difficulties Roentgen examination of the oesophagus at the local hospital had revealed a stricture about 5 cm long in the lower oesophagus (Fig 1a) Provisional diagnosis carcinoma of the oesophagus.

At roentgen examination with a light barium contrast medium and abdominal compression one month later a stricture about 1 cm long as well as a hernia were demonstrated (Fig 1c) Microscopy of biopsy tissue on two occasions inflammatory lesions no evidence of malignancy

Case 2 A woman aged 55 had for 10 months had increasing difficulty in swallowing Roentgen examination at the local hospital oesophageal stricture 5 cm long with its lower border a few centimeters above the cardia (Fig 2a)

The patient was referred to us with a probable carcinoma Roentgen examination one month later with a light barium contrast medium and abdominal compression hiatus hernia with a stricture about 1 cm long (Fig 2b) Microscopy of a biopsy specimen inflammation with ulceration but no signs of malignancy

Case 3 A man aged 61 had for some months had increasing difficulty in swallowing and finally could take only liquids

Roentgen examination at the local hospital a long marked stricture of the lower end of the oesophagus (Fig 3a) The abnormality was provisionally considered to be due to carcinoma Microscopy however revealed no evidence of malignancy Later at roentgen examination with a light barium contrast medium and abdominal compression a hernia and a stricture were found

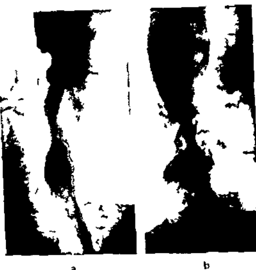
Owing to continued swallowing difficulties the patient was examined again 18 months



Fig. 1. a) Examination with a heavy barium contrast medium and no abdominal compression. The stricture appears to be long; a collapsed hernia is present. b) Light barium contrast medium and no abdominal compression. The stricture seems to be shorter and the hernia is more distinct. c) Light barium contrast medium and abdominal compression. A short and moderate stricture with adjacent ulcerations.

intrathoracic pressure (Valsalva's manoeuvre). To improve the diagnosis of hiatus hernia MARCHAND (1952) increased the intra-abdominal pressure with *the aid of a compression arrangement of the type usually employed in urography*. FREIDENFELT (1956) used double phase contrast roentgenography with gaseous distention of the region below the stricture by the incorporation of an effervescent powder (sodium bicarbonate and tartaric acid) in the barium swallow.

Our method. The patient is examined in prone position. The intra-abdominal pressure is increased by a large rubber bag wound around the abdomen and inflated by an electric fan to a pressure of about 17 cm water, which is maintained during the examination (SANDMARK 1963). The contrast medium is a viscous barium suspension with a specific gravity of 1 (Levitrast, Ferring). Four cases will illustrate the technique and its advantages.



a b

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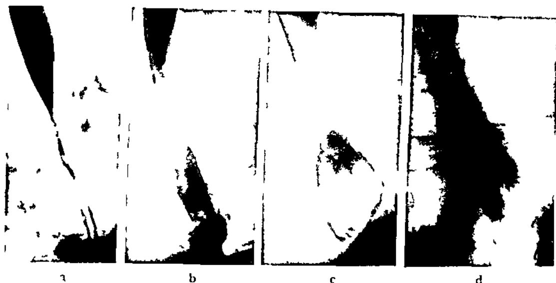


Fig 3 Examination with a heavy barium contrast medium and no abdominal compression Very long and marked stricture b) Heavy barium contrast medium and no abdominal compression As in (a) the hernia is not demonstrable c) Heavy barium contrast medium with compression d) Light barium contrast medium and compression A short stricture is present

later Examination with a conventional barium contrast medium and without abdominal compression a long moderate stricture of the lower end of the oesophagus (Fig 3b) The application of abdominal compression also disclosed a hernia (Fig 3c) Subsequent examination with a light barium contrast medium and abdominal compression the stricture was now much shorter (only about 2 cm long) (Fig 3d)

Case 4 A man aged 72 had for 6 months had progressive difficulty in swallowing Roentgen examination at the local hospital a 3 cm long stricture of the lower part of the oesophagus the cardiac end was not involved (Fig 4a) The patient was referred with probable carcinoma of the oesophagus

Roentgen examination with light barium contrast medium and abdominal compression a large hernia and a stricture about 1 cm long (Fig 4b) Microscopy of a biopsy specimen ulcerated oesophageal mucosa without signs of malignancy

Discussion

In a roentgen examination of a patient with oesophageal stenosing lesions in the erect position with conventional contrast medium and without increased abdominal pressure, that part of the oesophagus which is below the stricture will not be distended The stricture will appear longer than it really is and if a hernia is present it may remain concealed A collapsed hernia below the stricture may be interpreted as a part of the oesophagus (Figs 1a 2a 3a 3b 4a) Investigation of the lower end of the oesophagus below a stricture requires increased intra



Fig 4 a) Examination with a heavy barium contrast medium and no abdominal compression The stricture appears to be 3 cm long ulcer and collapsed hernia b) Light contrast medium and compression The stricture is 1 cm long

abdominal pressure The pressure should however not be applied too abruptly such as by Valsalva s manoeuvre because the abdominal viscera may then block the hiatus and prevent herniation of the stomach

The method described by MARCHAND is satisfactory but the advantage offered by SANDMARK s method is that the compression can be regulated and kept unchanged despite respiratory movements This is of particular importance in examinations for regurgitation The pillow used for the examination in the prone position must be large and hard so as really to support and compress the abdomen

The light viscous contrast medium employed is *not* carried off so rapidly by peristalsis and thereby allows the examiner more time to study the morphologic features of the oesophagus it also *gives better filling* below the stricture (Fig 1 a and b) and a clearer demonstration of a hernia (Fig 1b) Though a light contrast medium facilitates the examination abdominal compression is a sine qua non (Fig 1 b and c)

The patients were referred with long stenosing lesions of the lower part of the oesophagus The examination with abdominal compression and light contrast medium demonstrated that the stricture was much shorter than originally supposed and that all four patients also had hiatus herniation

SUMMARY

A method for the rational examination of strictures of the lower end of the oesophagus consisting in the use of abdominal compression and a light contrast medium is described.

ZUSAMMENFASSUNG

Es wird eine rationelle Methode zur Untersuchung von Stenosen am unteren Ösophagusende beschrieben. Die Methode benutzt Kompression des Bauches und ein dünnes Kontrastmittel.

RÉSUMÉ

Les auteurs décrivent une méthode d'examen rationnel des sténoses de l'extrémité inférieure de l'oesophage grâce à une compression abdominale et à un moyen de contraste dilué.

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OM THE ROENTGEN DEPARTMENT (DIRECTOR OVE MATTSSON) ERSTA SJUKHUS
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ULTRASONICS AS A COMPLEMENT TO ROENTGEN DIAGNOSIS

A preliminary communication

by

O MATTSSON

The first attempts to use ultrasonic reflection within the tissues of the body to obtain information about internal structures may be ascribed to DUSSIK and his collaborators who used the method for diagnostic purposes in the central nervous system as early as 1942 and 1947 FRENCH WILD & NEAL (1950) applied ultrasonic pulses to the location of cerebral tumours in post mortem material LEKSELL who later developed ultrasonic *techniques for* neurologic purpos s used ultrasound for the determination of the middle structures of the skull as early as 1955 Ultrasound was used by JANSSON in 1963 for certain special purposes such as for locating foreign bodies in the eye

The progress in this field has been rapid during the past few years and may largely be attributed to research work particularly by GORDON and HOWRY & HOLMES who have been the obvious leaders The activities of the working group at Denver Colorado are well known

A so-called A scan is generally employed The echo signal generates a peak on a horizontal axis on the screen of the oscilloscope the position of which in

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Fig 1



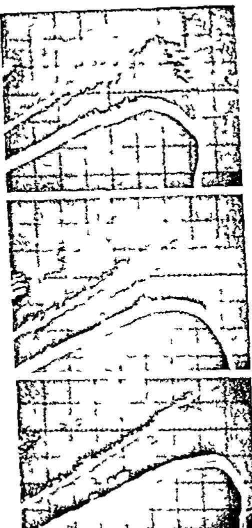
Fig 2

Fig 1 Roentgenogram of a fracture of the humerus A small amount of callus is visible

Fig 2 Ultrasonic recording from the lateral aspect of the upper arm The whole contour of the humerus is smooth (cf fig 3)

dicates the distance of the reflecting body from the source of sound A so called B scan has however recently been introduced, which means that the signal is made to generate a spot the intensity of which varies with the strength of the signal It is thus possible to obtain a bidimensional recording of the echo from the tissues if the electron beam of the oscilloscope can be made to follow a pattern governed by the position of the transducer i e the combined sound source and receiver The signals will therefore build up a model of the echo conditions in a region of the body in the form of sections A number of research workers have been engaged upon these problems, but the apparatus developed as a teamwork by HOLMES, HOWRY & GORDON seems to have been the most promising Radiologists with some exceptions (HOWRY et coll TAVFRAS), appear to have employed such apparatus only to a limited extent clinicians are the principal users

Investigations of the living body made possible by recording echo conditions in the form of sections should be regarded as useful complements to conventional roentgen diagnosis The recordings have been called ultrasonograms At



Fg 3

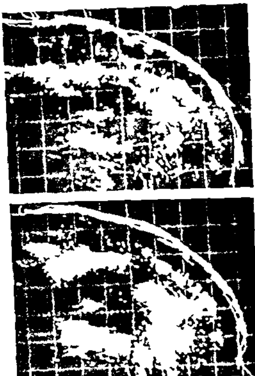


Fig 4

F g 3 Ult asonic recording from the med al asp ct of humerus with several parallel sectio (cf fig 1) The contour of the humerus is cons derable changed indicat ng e cessive amoi nt of t s ues in the region of the callus

F g 4 Two ultrason c record ngs from the abdomen ma l as close sections to include *the left k*id ey The pelvis well demonstrat ed

tempts have even been made to evaluate such recordings stereoscopically (HOWRY et coll 1956)

Sonographic recordings have a certain resemblance to radiographic tomograms and are often performed as a kind of transverse tomography The ex aminations made so far have mostly been limited *to the* abdomen apart from



Fig. 5

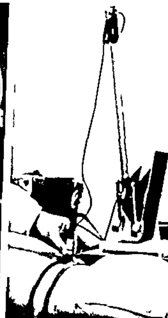


Fig. 6

Fig. 5. The transducer must be passed over the skin at a constant pressure. Two guiding rods provide an exact course and the same pressure conditions.

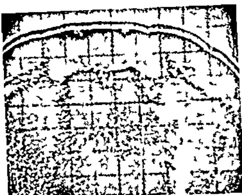
Fig. 6. An ultrasonic tomogram is made.

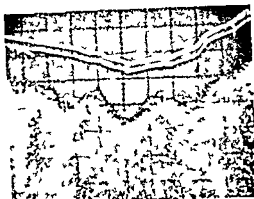
those of the central nervous system. The results obtained have usually given a rough representation of the object. Comparisons with results obtainable with roentgen rays have rarely been made although BRINKER, KING, TAVERAS and some others have published such comparisons.

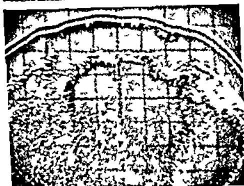
The question is whether roentgen and ultrasonic examinations merely complement each other or whether the ultrasonogram may offer something in addition. This investigation was intended to throw some light on the problem as well as to cover fields in which no ultrasonic studies have yet been made.

The majority of publications presented so far deal only with isolated sections of an object. Although these sections may produce a certain amount of information, a radiologist will miss the completeness afforded by a series of radiographic tomograms. It is quite natural that those who are not radiologists are unaccustomed to observing and evaluating sliced recordings and that they will fail to appreciate the multidimensional information of a tomographic roentgen series. They may be enthusiastic over an individual section but may not realize its high degree of incompleteness.

Our first consideration is therefore that a one plane rendering is not sufficient but that the general configuration should be built up from multiple images. Tomography for radiographic purpose is similar, an examination of an organ cannot be based on a single tomogram. The production of several ultrasonographic







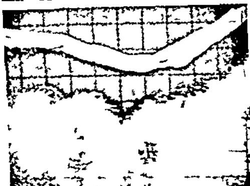


Fig 8

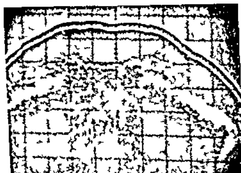


Fig 7

Fig 7 Horizontal ultrasonic sections through the lower part of the back at the level of the pelvis

Fig 8 Comparison between a single (top) and a complex recording from several superimposed ultrasonic scannings (bottom) Difference in contrast is evident

recordings will also reduce the disturbing effect of isolated reflections these cannot be avoided and are of little value Ultrasonics also seem to belong to the field of radiology since the techniques using absorbed radiation and reflected ultrasonic waves are closely related and well complement one another

The progress in ultrasonics should therefore proceed in intimate cooperation with roentgen diagnostics. There should be much more coordination than to date — as examinations made by means of ultrasonics have so far comprised only relatively stereotype routine applications.

The great importance of multiple sections may be illustrated by the following skeletal examination with the ultrasonic method as a complement to radiography taken from a current study of fractures and their healing. The distinctive echo effect from callus formation may sometimes serve as an indication of healing, which cannot equally well be evaluated in a conventional film. A fracture of the humerus, treated for six weeks, was seen on roentgen examination to have developed a small amount of periosteal callus on its medial aspect (Fig. 1). An ultrasonic recording from the lateral aspect of the arm is presented in Fig. 2, no irregularities as regards the echo along the lateral contour of the humerus are evident. This can easily be determined, the structures of the head and the greater tuberosity may be identified. Conditions of a wholly different *character may be observed on the medial aspect of the humerus (Fig. 3).* Three ultrasonic examinations parallel with the humeral diaphysis were made, each *section being somewhat displaced relative to the preceding one.* In this manner, a clearer presentation of the conditions in general was obtained than with a single section. All sections disclose considerable growth of the tissues around the fracture, thus indicating features that would not have been recorded roentgenographically.

Another region of the body in which the multiple section method seems to be indispensable for maximum information is the abdomen. Even only two sections from a series (as in Fig. 4) are considerably more useful than one.

The author uses a few simple tools to ensure that the examination may be performed with reasonable exactness and reproducibility. The so called transducer, which is a combination of sound generator and receiver, has been made to slide across the skin, previously dressed with a suitable oil or unguent. *The* general practice has been to pass over the skin manually at a fairly constant pressure but, owing to the difficulty of maintaining *the instrument at the same* level, an irregular skin contour, with a consequent loss of precision in the deep echoes, *has resulted. Soft pliable rods of triangular cross section* can be arranged as guides for the instrument in the respective sections of the skin (Fig. 5), and *the transducer* may be provided with two transverse adjustable pins for controlling the pressure applied to the skin. The instrument will now follow an absolutely exact course, which creates optimal conditions for well defined echo recordings.

The technique used for the examination is illustrated in Fig. 6. Precision in the location of the several sections is obtained without difficulty, *as well as*

complete reproducibility if complementary information is required Markings on the skin will indicate the various sections The transducer has been mounted on an arm which mechanically activates a computer system so that the location and orientation of the transducer and the ultrasonic beam can be constantly projected on the screen of the oscilloscope The suspension system of the transducer is seen in Fig 6 A polaroid camera can be used to record the oscillogram

The series of ultrasonic tomograms presented in Fig 7 show the extremely well defined skin contour The anatomy of the lower part of the back at the level of the pelvis is demonstrated The sections indicate the outlines of the ala ossis ischii and the tomographic presentation defines the anatomy

An important advantage gained with the technique may be mentioned As all oscillographic recordings are accumulated in a way similar to a photographic exposure parts with a slight echo may be better defined if several single-stroke recordings are summarized A kind of contrast increase in the recording is also obtained in this way which seems to be superior to what can be obtained by mere electric adjustments

An example of different degrees of contrast recording is given in Fig 8 in which a single and several superimposed identical recordings may be compared The recordings were made with a sagittal section from the dorsal part of the lumbar region The gain is obvious

The experiences made in the now reported study will be used for the study of practical applications relating to the skeleton its injuries and healing and to investigations of the possibilities of extracting additional information about abdominal organs such as the pancreas The technique developed for exactly defining the sectional positions will be employed

SUMMARY

Introductory studies of ultrasonic techniques as a complement to roentgen diagnostic are presented The importance of multiple sections and their exact localization similar to the conditions obtaining in roentgen tomography are discussed

ZUSAMMENFASSUNG

Bericht über vorläufige Untersuchungen zur Ergänzung der Röntgendiagnostik mit der Ultraschalltechnik Es wird hervorgehoben dass es wichtig ist reihenartige Untersuchungen mit genauer Lokalization vorzunehmen ähnlich wie die Serienschnitte bei der Tomographie

RÉSUMÉ

Présentation de recherches sur les techniques ultrasoniques considérées comme un complément du diagnostic radiologique. L'auteur examine l'intérêt de coupes multiples et de leur situation exacte, semblables aux conditions dans lesquelles on fait la tomographie radiologique.

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RADIOLOGIC STUDY OF INTRACRANIAL CALCIFICATIONS IN CONGENITAL TOXOPLASMOSIS

by

HERBERT MUSSBICHLER

Many clinical reports of toxoplasmic infections have been published since WOLF, COWEN & PAIGE (1939) proved that toxoplasmosis could occur in human subjects. While the postnatal type of infection mostly pursues a subclinical course with some glandular involvement, the fetal form selectively affects the nervous system and may result in hydrocephalus and mental retardation. Lesions of the choroids, ciliary body or retina of the eyes are also almost invariably present.

The lesions in the brain and eye start as acute vasculitis followed by necrosis and cellular infiltration in the cortex, meninges, white matter, basal ganglia, brain stem and spinal cord. The toxoplasmic parasites are found in clusters intracellularly as pseudocysts and may also be sparsely distributed between the cells. As necrosis continues, calcium is deposited and organisation takes place (POTTER 1961). Lesions of the skeletal and heart muscles and the lungs have been described (ZUELZER 1944, Wolf et coll. 1937, KEAN & GROCOTT 1948, DUBLIN 1954) but calcifications have been found to be limited to the intracranial structures.

From the Department of Diagnostic Radiology (Director: U. Rudhe) of the Pediatric Clinic, Karolinska Sjukhuset, Stockholm, and Roentgen Department II (Director: B. Liliequist), University of Umeå, Sweden. Submitted for publication 2 March 1967.

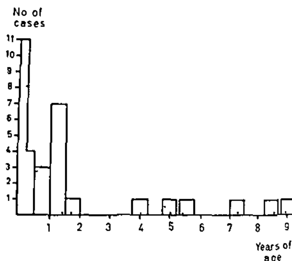


Fig 1 Distribution of cases by age at the time of the first examination

The calcium deposits, usually described as nodular, multiple flecks and curvilinear streaks are scattered throughout the brain without any characteristic distribution (BRODFUR 1965, LINDGREN 1954 MASHERPA & VALENTINO 1959 POTTER 1961, TAVERAS et coll 1964) MASHERPA described two types of calcifications multiple dense round foci 1 to 3 mm in diameter, scattered in the white matter and more often in the periventricular areas of the occipito-parietal and temporal regions, and curvilinear streaks in the basal ganglia mostly in the head of the caudate nucleus Nodular calcifications when combined with linear calcifications may be pathognomonic of toxoplasmosis

The differential diagnosis of intracerebral calcifications of infectious origin should according to NEUHAUSER & TUCKER include toxoplasmosis torulosis histoplasmosis blastomycosis and possibly malaria In tuberous sclerosis nodular and curvilinear calcifications may be present and be similar to those in toxoplasmosis (LINDGREN) In cysticercosis trichinosis and torulosis numerous faint and punctate deposits of calcium are irregularly scattered through the brain



Fig 2 Calcifications in cerebral structures choroid plexus (●) ependyma (— — — —) meninges (— — — —) and caudate nucleus ( )

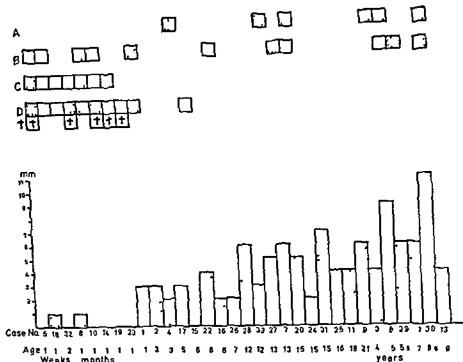


Fig. Case material arranged according to age. Calcifications in choroid plexus (A), ependyma (B), meninges (C), caudate nucleus (D) and patients who died early in life (+). The scattered calcifications are marked by granules in the columns, sparse granules being single calcifications. The distribution of the calcification was unequal in both hemispheres in Cases 28, 29 and 30. The scale on the ordinate indicates the largest diameter of the calcium deposits in millimeters.

(MASHERPA). The megalocytic inclusion disease is characterised by extensive calcifications chiefly located subependymally and symmetrically on both sides mostly in the walls of the dilated lateral ventricles (CAFFEY, POTTER, TAVERAS et coll.). Intracerebral calcifications during early infancy are however generally due to toxoplasmosis (CAFFEY).

The literature on toxoplasmic infections from the clinical and bacteriologic points of view is extensive. Radiologic publications are however few and essentially limited to case reports. DYKE et coll. (1942) described eight cases with intracranial calcifications, the largest series the author could find reported.

The purpose of the present investigation was to analyse the type, distribution and progress of the intracranial calcifications in a large series of clinically well documented cases of congenital toxoplasmosis.

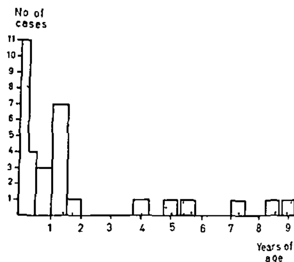


Fig 1 Distribution of cases by age at the time of the first examination

The calcium deposits, usually described as nodular, multiple flecks and curvilinear streaks are scattered throughout the brain without any characteristic distribution (BRODFUR 1965 LINDGREN 1954 MASHERPA & VALENTINO 1959, POTTER 1961, LAVRAS et coll 1964) MASHERPA described two types of calcifications multiple dense round foci, 1 to 3 mm in diameter, scattered in the white matter and more often in the periventricular areas of the occipito-parietal and temporal regions and curvilinear streaks in the basal ganglia, mostly in the head of the caudate nucleus Nodular calcifications when combined with linear calcifications may be pathognomonic of toxoplasmosis

The differential diagnosis of intracerebral calcifications of infectious origin should according to NEUHAUSER & TUCKER include toxoplasmosis torulosis, histoplasmosis blastomycosis and possibly malaria In tuberous sclerosis, nodular and curvilinear calcifications may be present and be similar to those in toxoplasmosis (LINDGREN) In cysticercosis trichinosis and torulosis, numerous faint and punctate deposits of calcium are irregularly scattered through the brain



Fig 2 Calcifications in cerebral structures choroid plexus (●) ependyma (— — — —) meninges (— — — —) and caudate nucleus ( )

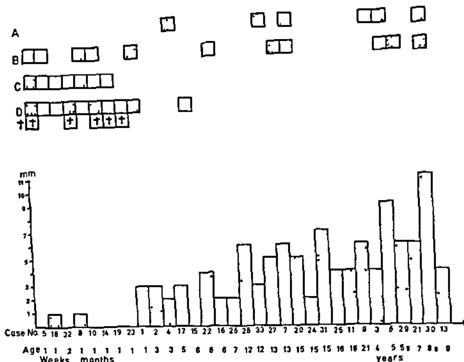


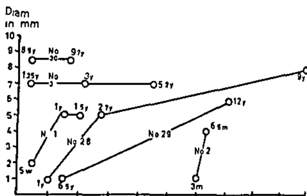
Fig 3 Case material arranged according to age Calcifications in choroid plexus (A) ependyma (B) meninges (C) caudate nucleus (D) and patients who died early in life (+) The scattered calcifications are marked by granules in the columns sparse granules being single calcifications The distribution of the calcifications was unequal in both hemispheres in Cases 28 29 and 30 The scale in the ordinate indicates the largest diameter of the calcium deposits in millimeters

(Masherpa) The megalocytic inclusion disease is characterised by extensive calcifications chiefly located subependymally and symmetrically on both sides mostly in the walls of the dilated lateral ventricles (Caffey Potter Taveras et coll) Intracerebral calcifications during early infancy are however generally due to toxoplasmosis (Caffey)

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Fig 4 Control of 6 cases with intracranial calcifications at different ages Every case is indicated by Case No age in weeks (w), months (m), or years (y) at the time of investigation The diameter of the corresponding deposits is given by the millimetre scale on the ordinate Nearly all the calcifications increased in size in Cases 1 and 28, and further calcifications appeared in Case 2 An increase of only one deposit out of eight could be demonstrated in Case 29 Cases 30 and 31 remained unchanged



Material and Method The case material consists of 32 infants and children, 19 of which were female and 13 males The age distribution is given in Fig 1

The clinical diagnosis was based on a positive dye test or positive complement fixation test, or both All cases of intracranial calcifications in which the diagnosis was not verified by these tests were eliminated from the series No autopsy studies were performed

The roentgen examinations were carried out on a Lysholm table at 70 cm FFD in frontal, semi axial, axial and lateral projections

Results

The shape of the calcifications varied considerably The linear shape of calcifications described by some authors could often be identified as plaques when the projection was changed The calcifications were classified as granulomatous and massive, in agreement with the pathologic classification of DUBLIN (1954) The former were usually small and reticular or amorphous in appearance, the massive calcifications included round, polycyclic, irregular or plaque like deposits The deposits were either irregularly scattered in the brain or situated in certain brain structures (Fig 2) Both types appeared in 12 cases, scattered calcifications alone in 13 and calcifications in certain brain structures in 7 cases (Fig 3)

Scattered calcifications were present in the frontal region in 23 cases, in the parietal region in 30 in the occipital in 7, and in the temporal region in 6 cases The relative number of scattered calcifications in these regions are indicated by +, ++, +++, corresponding to 1—4 to 5—10 and, respectively to more than 10 calcifications the relative frequency was then 31 + frontally 75 + parietally, 8 + temporally and 7 + occipitally The calcifications within

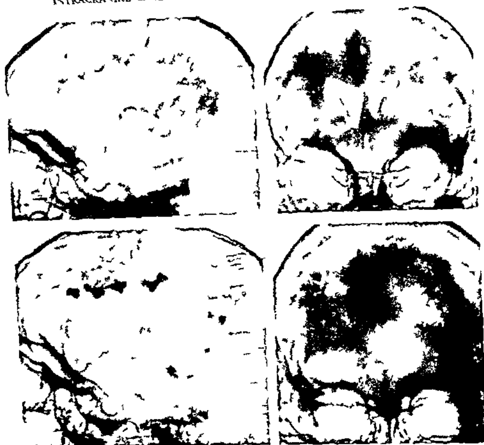


Fig 5 *Case 28* Follow up examination of a child one year old (upper views) and at the age of 9 years (lower views) Dilatation of the right lateral ventricle and scattered calcifications in the right hemisphere which progressed over several years

these areas were situated mostly in the medial and upper regions and were less frequent basally No calcifications could be *identified* with certainty in the subtentorial and upper cervical regions

The calcifications were in some cases isolated (*in Fig 3* indicated by sparse granules) while in others they were situated predominantly in one hemisphere The size of the calcifications can be *derived from* Figs 3 and 4 the calcifications generally enlarged with age They *ranged from* small granules up to 11 mm in diameter In older children they often formed *conglomerations* (Figs 5 and 6) The contrast of the deposits generally increased relative to their size

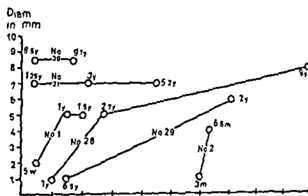


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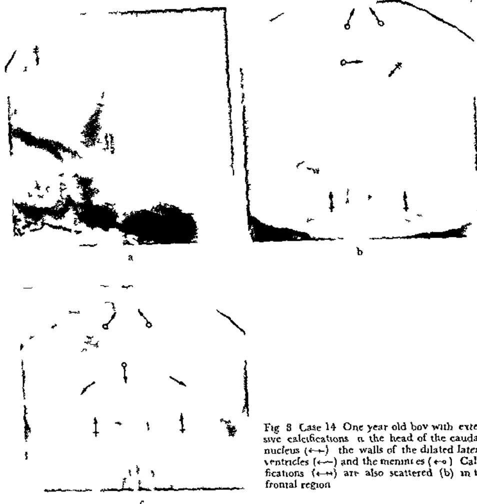


Fig 8 Case 14 One year old boy with extensive calcifications in the head of the caudate nucleus (←+) the walls of the dilated lateral ventricles (←—) and the meninges (←o) Calcifications (←↔) are also scattered (b) in the frontal region

caudate nucleus the meninges choroid plexuses and subependymally they appeared often together with the scattered calcifications (*Fig* 3)

In the caudate nucleus reticular calcifications were present in 9 cases they were always bilateral and mostly lay in the head (Figs 7 and 8) In 4 cases there were also deposits in the body of the caudate *nucleus* These reticular calcifications in the caudate nucleus were found only in infants up to 4 weeks old Atypical calcified single plaques in the head of the caudate nucleus were present only in one child (of 6 months) (Fig 9) Meningeal calcifications (Fig 3) were best



Fig 6 Case 30 *Encephalograms of a 8 1/2 year old boy with extensive calcifications in the choroid plexus on the surface of the thalamus (arrows)* Scattered calcifications mostly in the right parieto temporal region The texture of the deposits indicates that they grew in eccentric directions

Fig 7 Case 5 Five week old girl with reticular calcifications predominantly in the walls of the dilated lateral ventricles (←—) the adjacent parts of the caudate nucleus (←+) and the meninges (←o) Some scattered calcifications are present at the periphery



Fig 10 Case 2 Encephalograms of a 3 month-old boy with stenosis of the aqueduct and dilatation of the cisterns Plaque like calcifications scattered in the upper lower and posterior parietal regions

cervical regions (the latter confirming the findings of CAFFEY) Although the cerebellum adjacent to the fourth ventricle the ependyma of the aqueduct and the choroid plexuses of the eyes according to the pathologists are the regions mostly involved no calcifications in these areas were observed in the present investigation It must however be stressed that calcium deposits in these regions are difficult to locate in roentgenograms because of the superimposition of skeletal elements Calcifications in the orbits as described by PETROVICKY 1955, were not observed in this series

The great variation in the scattered calcifications prevents their being regarded as typical of toxoplasmosis The calcifications in certain of the brain structures in the caudate nucleus, choroid plexuses meninges and subependyma are of course characteristic though some of them have also been described in cytomegalic inclusion disease It was significant in this series that the calcifications were present in multiple areas Therefore calcifications present solely in the choroid plexuses should not be regarded as toxoplasmic residues as several authors have done (LORENZ 1950 SCHOEPS 1951) Calcifications in the meninges have not been previously described probably due to the fact that correct projections were not utilized for their delineation The calcific deposits mean involvement of the meninges as observed by pathologists (DUBLIN BLACKWOOD et coll) Calcifications in the meninges and caudate nucleus which were found only in the youngest children who died early indicate a poor prognosis

Case 31 in which sparse scattered calcifications were discovered accidentally was without symptoms other cases with similar calcifications evidently had a



Fig 9 Case 15 Six month old boy with atypical single calcifications in the head of the caudate nucleus

plaque like deposits (Figs 7 and 8) Their size varied from small to large and they appeared mostly on the medial surface of the brain, they were invariably bilateral Calcifications in the caudate nucleus were observed in all these cases (Fig 3)

Ependymal or subependymal calcifications were present in 11 cases The granulomatous and plaque like deposits in the basal ganglia were often situated ependymally or subependymally, outlining the walls of the ventricles (Figs 7 and 8) Five of the 9 cases with calcifications of the caudate nucleus belonged to this group In 6 cases the deposits were on the surface of the thalamus and in three of these a choroid plexus was also calcified (Fig 6)

Calcifications were present *in the choroid plexus* in a total of 6 cases They were granular or massive and situated at the site at which non pathologic calcifications may occur The toxoplasmic calcifications were however always associated with calcifications in other locations the diameter of the deposits ranged from 2 to 10 mm

Six cases were re examined The calcifications in two of them were unchanged but in four cases they had increased in size (Figs 4 and 5) Fig 4 illustrates the maximum enlargement of the calcifications in intervals from some months up to 8 years A further calcification appeared in Case 2 and one of the 8 deposits in Case 29 had increased in size over a period of 5 1/2 years

Discussion

The scattered calcifications were situated mostly in the upper and medial regions of the skull and seldom basally, also, they sometimes occurred in only one hemisphere No calcifications were present in the subtentorial or upper

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bad prognosis (Fig 10) The extent of the scattered calcifications apparently does not necessarily conform with the clinical signs and the course of the disease

The increase in size and number of the calcifications, and the appearance of new deposits in our roentgen control studies may lend support to the clinical observations of HAFSTROM (1957) and LAGERCRANTZ (1967) that the process of healing may be prolonged and that exacerbations may occur months or even years after the onset of the infection

SUMMARY

A systematic, roentgenographic study of 32 cases of intracranial calcifications due to the prenatal form of toxoplasmosis is reported The calcifications are classified into those scattered irregularly in the brain and those lying in certain structures Calcifications of the meninges due to toxoplasmosis have apparently not been described before but were dem onstrated in 7 of the present cases No calcifications were seen in the posterior fossa the upper cervical region or the orbit The calcification process may continue for many years after the onset

ZUSAMMENFASSUNG

Es wurden 32 Patienten mit intrakraniellen Verkalkungen als Folge der pranatalen Form der Toxoplasmose rontgenologisch studiert Zwei Arten von Verkalkungen werden unter schieden solche die im Gehirn unregelmassig verstreut sind und solche die in gewissen Hirnstrukturen vorkommen Meningeal Verkalkungen die bei Toxoplasmose bisher nicht beschrieben worden sind wurden bei 7 Patienten nachgewiesen Keine Verkalkungen wurden *in der hinteren Schadelgrube der oberen Cervicalmarksregion oder der Orbita beobachtet* Der Verkalkungsvorgang kann sich uber viele Jahre hin erstrecken

RÉSUMÉ

L auteur presente une etude radiologique systematique de 32 cas de calcifications intra cramennes dues à la forme prenatale de la toxoplasmose Il distingue les calcifications qui sont dispersees irregulièrement dans le cerveau et celles qui sont situees dans *certaines* structures Il semble que les calfications meningees dues a la toxoplasmose n aient pas ete *decrites auparavant mais elles ont ete mises en evidence* dans 7 de ces cas L auteur n a pas observe de calcifications dans la fosse posterieure la region cervicale superieure ni l orbite Le processus de calcification peut continuer pendant de nombreuses annees apres le début

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Fig 1 Anterior and lateral projections of a normal brain scintigram




Fig 2 Brain scintigram showing meningioma on the right side

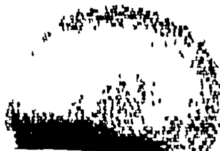



Fig 3 Brain scintigram showing grade I astrocytoma on the left side

FROM THE DEPARTMENT OF RADIATION THERAPY AND NUCLEAR MEDICINE, THE CLEVELAND CLINIC FOUNDATION, CLEVELAND, OHIO, USA

ISOTOPE SCANNING OF BRAIN TUMORS USING ^{99m}Tc

by

EDGAR J. FILSON and ANTONIO RODRIGUEZ ANTUNEZ

Biopsy proved brain tumors were recorded in 97 cases at the Cleveland Clinic during the period from January 1965 to December 1966. In each case a brain scintigram had been obtained after intravenous administration of 8—10 mCi of ^{99m}Tc pertechnetate. An 8 inch crystal rectilinear scanner was used in 54 cases and a 3 inch rectilinear scanner in 43 cases. An analysis of our experience is now presented.

The pertechnetate ^{99m}Tc appears to be an ideal agent for scanning for two reasons (HARPER et coll. 1964): the short half life (six hours) permits a large amount of radioactive substance to be injected, while at the same time a small dose of radiation is received by the patient. This results in a high count rate which improves the statistics of counting. The 8 inch rectilinear scanner permitted an average of 30 000 counts per minute. The high count rate permits the use of a rapid scanning speed, the average time for a single view of the brain being about 7 minutes.

Scintigraphic tumor localization

In the normal brain scintigram (Fig. 1) the calvaria is clearly outlined. Because the histochemical blood brain barrier remains intact, the radioactivity is confined within the blood vascular spaces of the diploe in the dural sinuses. The

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Table 1

Types of tumor and sites not outlined in ten scintigrams of the series

Type of tumor	Site	Number of cases
Metastasis	Left cerebellum	1
Medulloblastom	Right cerebellum	1
Cystic astrocytoma	Left cerebellum	1
Oligodendroglioma	Left parietal lobe	1
Astrocytoma	Frontotemporal lobe	5

Table 2

Analysis of the accuracy of scintigrams in the 97 cases with brain tumor verified by biopsy

Scanners	Number of scintigrams	Correct diagnosis in number of cases	Rate of accuracy in per cent
Both	97	87	90
8-inch	54	51	94
3-inch	43	36	83

Ten of the cases were infratentorial and 87 supratentorial. The histologic types of the tumors and their location in each one of the ten cases in which the tumor was not visible on the scintigram are given in Table 1.

The diagnostic accuracy in this series utilizing ^{99m}Tc and an 8 inch rectilinear scanner was 94 per cent in comparison with the 83 per cent accuracy obtained with the 3 inch scanner, as may be seen from Table 2. The overall accuracy of 90 per cent compares favorably with other reports on ^{99m}Tc. It has also been stated that slowly growing, well differentiated gliomas concentrate only small amounts of radioactive material. Tumors at the base of the brain are frequently hidden by the greatly increased vascularity of this region, which obscures the uptake of radioactive material by the tumor.

SUMMARY

Brain scanning after administration of ^{99m}Tc was performed in 97 patients, all with intracranial tumors proved at biopsy. This isotope appears to be ideal for scanning because of the low radiation dose to the patient and the high counting rate obtained. The authors believe that the statistics of scanning may be improved by the use of this isotope and an 8 inch crystal rectilinear scanner and thus make rapid linear brain scanning feasible. The overall diagnostic accuracy was 90 per cent in the series reported upon.

normal, relatively avascular, cerebral tissue stands out in sharp relief as a region 'colder' than the blood vascular spaces The excellent outline of the calvaria is an accurate representation of the true image of that structure of the patient and aids in the localization of any abnormality

The scanner is set by *determining the maximum counts per minute at the mid* portion of the sagittal sinus A brain scintigram is technically acceptable only when the entire outline of the skull is demonstrated We believe that a brain scintigram on which the outline of the skull has to be drawn with a wax pencil is technically unsatisfactory The sagittal sinus should show gradually increasing radioactivity from the vertex to the lambda on the lateral view, which reflects a normally increasing blood load as the sinus progresses toward the torcular Herophili

When the background suppression is of a magnitude to obliterate the normal *anatomic landmarks (sagittal sinus, diploe), there are more chances of missing* the lesions with radioactive concentration equal to or less than that of the blood pool However we do agree with Quinn Ciric & Hauser (1965) that the display of normal intracranial vascular structures on the pertechnetate brain scan may mask the visualization of abnormal radioisotope concentrations in the base of the brain and posterior fossa

The increased uptake of ^{99m}Tc in a meningioma, later confirmed at operation is shown in Fig 2 Meningiomas, even though slow growing, concentrate *radioactivity* well because of their profuse vascularity and disruption of the blood brain *barrier Less radioactive uptake is seen in slower growing or* less vascular tumors such as a grade I astrocytoma (Fig 3) but the uptake even by those tumors is usually sufficient for diagnosis

Results and Comments

Interest in our diagnostic accuracy with this new agent, ^{99m}Tc prompted an analysis of the 97 cases of brain tumor proved by biopsy at the Cleveland Clinic *from January 1965 to December 1966 At least one ^{99m}Tc brain* scintigram had been made for each patient, and these were reviewed to determine whether or not a tumor could be demonstrated The tumor was outlined in 87 of the 97 cases In fourteen of these there were multiple regions of uptake compatible with metastases to the brain A positive biopsy was also obtained in each of these cases

The cell types of the 97 tumors are given below

Astrocytoma (grades I II III)	29
Glioblastoma	19
Meningioma	19
Other tumors	15
Metastases	15

FROM THE DEPARTMENT OF DIAGNOSTIC RADIOLOGY (DIRECTOR PROF F KNUTSSON) THE UNIVERSITY HOSPITAL UPSALA, SWEDEN

SIZE AND DEVELOPMENT OF THE CEREBRAL VENTRICULAR SYSTEM IN CHILDHOOD

by

HERMAN LODIN

Most text books of neuroradiology give detailed descriptions of the normal roentgenologic anatomy in the adult As a rule however the topography of the ventricular cisternal and cerebral vascular systems during the period of growth is treated only briefly and in general terms Thus there appears to be no collective presentation of the changes that take place in the relationships between these systems and the cranial bones during growth This also holds for the changes in size undergone by the ventricular system and the cisterns

We therefore considered it of value to investigate these conditions in a series of normal encephalographies and cerebral angiographies in children up to the age of 15 years Increased knowledge of the roentgenologic anatomy in the child should help to eliminate diagnostic uncertainty and errors of judgement which may result if only the adult anatomy is known

The investigation has been undertaken in four parts The present paper will be followed by a study of the normal changes in position of the ventricular system (LODIN 1968) a study of anatomical relationships of the cisterns (CARLSSON & LODIN 1969) and finally by a treatise on the gross topography of the cerebral vascular system (BERGSTROM LODIN & OTTANDER 1969)

Submitted for publication 29 February 1968

ZUSAMMENFASSUNG

Scanning des Gehirns nach Verabreichung von ^{99m}Tc wurde an 97 Patienten vorgenommen bei denen intrakranielle Tumoren durch Biopsie festgestellt wurden Das Isotop scheint auf Grund der niedrigen Strahlendosis und der hohen Zahlgeschwindigkeit fur Szintigraphie besonders geeignet zu sein Die Verfasser glauben dass statistisch bessere Resultate von Scanning bei Verwendung von ^{99m}Tc zusammen mit einem geradlinigen 8 Zoll Kristall Scanner gewonnen werden konnen welches schnelle geradlinige Gehirnszintigraphie erlauben wird Die durchschnittliche diagnostische Genauigkeit war 90 Prozent in dieser Serie

RÉSUMÉ

Quatre vingt dix sept malades tous atteints de tumeur intracranienne prouvee par biopsie ont subi une scintigraphie cérébrale après injection de ^{99m}Tc Cet isotope parait etre idéal pour la scintigraphie en raison de la faible dose de radiation et du fort taux de comptage obtenu On suppose qu utilise avec un scintigraphe linéaire a cristal de 8 pouces il améliorera les résultats de la scintigraphie et permettra une scintigraphie linéaire rapide du cerveau Dans cette serie il a donné 90 % de diagnostics exacts

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QUINN III J L CIRIC I and HAUSER W N Analysis of 96 abnormal brain scans using technetium 99m (pertechnetate form) J A M A 194 (1965) 157



Fig 2 Quotients of the anterior horn in the respective age groups Upper curve the whole material (fig 1a) lower curve the strictly selected material (fig 1b) Mean values



Fig 3 Widths of the anterior horns in millimetres Unbroken line right horn dotted line left horn Mean values

The question of delimitation between normal and pathologic values with due regard to the range of normal variations is always open to discussion and cannot be answered with certainty The use of the quotients suggested by Evans and by Lindgren appears however to allow a practical possibility of studying the average normal relations between the ventricular system and the cranial cavity The mean values for quotients in different age groups can be compared and in this way information on the dimensional development of the ventricular system can be obtained

A study was made of a series of normal encephalographies with special regard to the size of certain components of the ventricular system at different ages No such investigation appears to have been presented previously Gollnitz (1951) reported on a series of encephalographies representing 130 children in ages between 4 and 14 years but no quantitative results or results of comparisons between different age groups were given

Material This normal material of encephalographies was selected from a clinical series according to certain principles Thus the entire ventricular system should have been examined by the fractionated encephalography method with an adequate amount of gas In all cases the ventricular system should have a symmetrically harmonic appearance and cases with signs of malformation displacement or deformation subdural air or cortical atrophy were excluded A further criterion for inclusion in the material was that the Lindgren ratio should apply for the upper normal limit of the width of the anterior horn i e this width should not exceed a third of the homolateral half of the inner cranial diameter

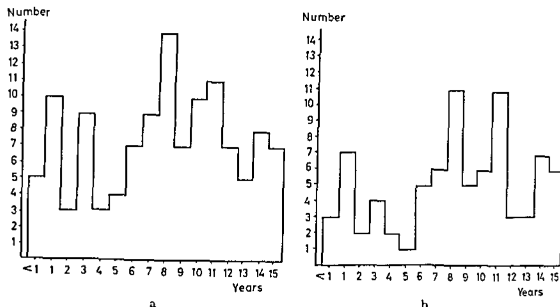


Fig 1 a) Age distribution of the total material with a quotient of ≤ 0 33 for the anterior horn b) Age distribution of the more selected material with a quotient of ≤ 0 30 for the anterior horn

Different methods of measurement have been used for determining from encephalograms the normal size and volume of the ventricular system in the adult Because of the large individual variations in the distances measured directly, many of these methods have gained no practical importance

As has been stressed by EVANS (1942), LINDGREN (1951), BERG & LONNUM (1966) among others, the shape and size of the skull have considerable influence on the form and dimensions of the ventricular system This factor must be taken into consideration when attempting to assess the significance of the size of this system EVANS, and LINDGREN recommended the use of the relations between the widths of the anterior horns and the inner cranial diameter as a practical measure of the relative size of the ventricular system EVANS (1942) gave an index of ≥0 31 as a safe expression of dilatation of the ventricular system, while LINDGREN (1951) recommended as the upper normal limit that the width of the anterior horn should not exceed about a third of half the inner cranial diameter Opinions vary as to the placement of the so called normal limit BERG & LONNUM (1966) favour the method of ENGESET & LONNUM (normal value for septum caudate line 15 mm and for width of third ventricle 8 mm), with the addition of 1 mm per 10 mm increase in cranial width within the normal values given for this width (155 to 180 mm as measured on the film) These authors found good agreement between this and other methods, including that of EVANS



Fig 6 Height of fourth ventricle (H—F) Mean values

clearly that the quotients increase up to the age of 2 years but then remain on the whole unchanged during the rest of the growth period

The mean values for the widths of the respective anterior horns measured on the roentgen films are given in Fig 3 The unbroken line represents the right anterior and the dotted line the left anterior horn The absolute widths of the anterior horns increase up to the age of 2 years after which they do not on an average vary noteworthily

Third ventricle In Fig 4 the frontal diameter of the third ventricle is shown, both in the total material (unbroken line) and in the more strictly selected material with a quotient of ⩽0 30 for the anterior horn (dotted line) It appears that this more strict selection of the material does not influence the curve for the width of the third ventricle it is also evident that this width is somewhat smaller during the first year of life

The width of the third ventricle is given in Fig 5 in two groups in which the upper limits for this width are placed at different levels The upper curve (unbroken line) represents all measurable third ventricles with a width of ⩽8 mm (a total of 85) and the lower curve (dotted line) those with a width of ⩽5 mm a total of 40) The curve for the 8 mm group displays in principle the same result as Fig 4 while the 5 mm curve because of the smaller number of cases does not permit any conclusions to be drawn

Fourth ventricle The height of the fourth ventricle is given in Fig 6 It may be seen that this value increases up to the age of 2 years but that no essential change takes place later

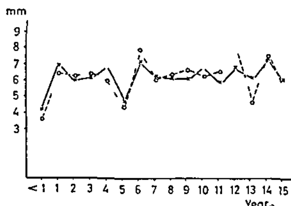


Fig 4 Width of third ventricle Unbroken line material fig 1a dotted line material fig 1b Mean values

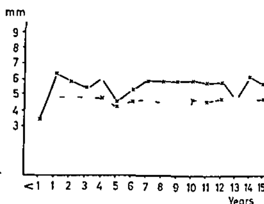


Fig 5 Width of third ventricle Unbroken line upper limit=8 mm dotted line upper limit=5 mm Mean values

After selection in this way, the total material comprised 119 encephalographies the age distribution is given in Fig 1

Encephalographic and Measurement techniques All encephalographies were performed on a Lysholm skull table The amount of air used was always adequate for the measurement of the widths of the anterior horns and third ventricle with a symmetrical distribution of air within the two anterior horns The widths of the latter were measured on an a p film taken in supine position with the central ray parallel with a line between the outer canthus and external auditory meatus and the ratios between the widths of the respective anterior horns and the corresponding halves of the inner cranial diameter were calculated The maximal frontal width of the third ventricle was measured in the same projection The height of the fourth ventricle, i e the distance between its base and the fastigium was measured on a lateral film taken sitting (autotomogram) *No correction* was made with the length and width of the skull

The *mean values* for the quotients calculated and the distances measured in the different age groups are given in Figs 2 to 6

Results

Anterior horns of lateral ventricles The upper curve of Fig 2 depicts the mean values for the quotients in the respective age groups in the whole material (i e in those cases with a quotient for the anterior horns of ≤0 33) The lower curve gives the mean values for the quotients in cases in which these were ≤0 30 and thus represents a more strictly selected material The latter curve illustrates more



Fig 6 Height of fourth ventricle (H—F) Mean values

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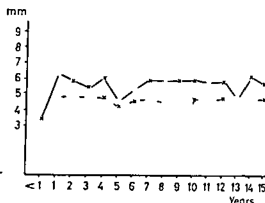


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to draw any definite conclusions as to which of these quotients is the more appropriate It seems probable however that for children a quotient of 0 30 best corre ponds with the true condition On the other hand if SCHIFFSMANN s normal index were used, corresponding to a quotient of 0 25 the material of 119 encephalographie now presented would be reduced to 11 cases Such a normal limit does not appear realistic

SUMMARY

A series of 119 normal encephalographies in children of up to 15 years of age was surveyed to determine the relative rapidity of the phase of development of th ventricular system Th physiologic increase in width of the ventricular system was found to take place mainly during the first two years of life The results indicate that as a practical quotient in evaluat in the size of the ventricular system in children the upper normal limit for the width of the anterior horn should be three tenths of half the inner cranial diameter

ZUSAMMENFASSUNG

Um die relative Schnelli keit der Entwicklung der Gehirnventrikel zu studieren wurde ein Material von 119 normalen Encephalo raphien von Kindern bis zum Alter von 15 Jahren ubersehen Es wurde ermittelt dass die physiologische Zunahme der Weite des Ventrikel sy tem hauptsachlich in d n er ten zwei Lebensjahren stattfindet Die Resultate deuten da auf hin dass der maximale normale Grenzw ert der Weite des Vorderhorns drei Zehntel des halben Gehirndiameters sein sollte um ein praktischer Quotient in der Ausw ertung des Ventrikel y temes in Kindern zu sein

RESUME

L auteur a examine une serie de 119 encephalographies normales chez d enfants jusqu à 15 ans d a e pour determiner la vites.e relative des phase de developpement du systeme ventriculaire Il s est montre que l augmentation physiologique de la largeur du systeme ventriculaire se realise principalement p ndant les deux premieres anne s de la vie Les re ultats de cette etude montrent que pour apprecier les dimensions d systeme ventriculaire hez l enfant on peut considerer que la limite superieure normale de la largeur de la corne anterieure est les trois dixi mes de la moitie du diametre interne du crane

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Discussion

The material presented is relatively limited, like all similar materials It never theless seems justifiable to draw certain conclusions from the results obtained The curves illustrating the width of the anterior horn and the height of the fourth ventricle indicate that the physiologic increase in the width of the ventricular system takes place during the first years of life A similar tendency may be ob served for the third ventricle

The rapid increase in the width of the anterior horn during the first year of life coincides with the rapid growth of the cerebrum that occurs at this time It is evident from Fig 3 that the left is generally somewhat wider than the right lateral ventricle Because of the small number of cases below one year of age, it is uncertain whether or not it is only by chance that the lateral ventricles have the same width during the first year of life On the other hand, the motor development of the child proceeds rapidly during the first six months with the rapid growth of the cerebrum A difference in width between the lateral ventricles in the 1 year group is notable This is possibly an early expression of the rela tionship that might be expected between right handedness and a somewhat wider left lateral ventricle According to GOLLNITZ, however, this difference is always pathological and an expression of the greater vulnerability of the predominating left cerebral hemisphere

With regard to the third ventricle, no definite idea of its width during the first year of life has been obtained It appears from Fig 4, however, that at the age of 1 to 2 years, at least, it has reached a width that is normal for the remainder of the growth period This seems to hold both when the material is selected ac cording to the index for the width of the anterior horn (0 33 or 0 30) and when an upper limit of 8 mm is set for the width of the third ventricle An upper normal limit of 5 mm was also used In this case, however the material was so greatly reduced that it was impossible to evaluate the development tendency, and the accuracy of this value as a normal limit seems questionable

The growth of the fourth ventricle (as assessed from its height) appears to be mainly terminated by the age of 2 years, after this time no change in height was evident Taking the enlargement factor into consideration, a mean value of 14 mm obtained from the film corresponds to about 12 5 mm This is in complete agreement with the observations made by AMUNDSEN & GRIMSRUD

The criteria for selection are always open to discussion in evaluations of clin ically normal series It is evident from Fig 2 that when the upper limit for the quotient is placed at 0 30, there is a more distinct change in size than when the value of about a third, recommended by LINDGREN for adults is used *The lowest* age groups in the present material are however relatively small, and it is difficult

FROM ROENTGENDIAGNOSTIC DEPARTMENT I (DIRECTOR PROF O OLSSON)
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REGIONAL CEREBRAL BLOOD FLOW IN INTRACRANIAL TUMOURS

by

STEN CRONQVIST and FRANK AGEE

An intracranial tumour may be demonstrated angiographically either as an avascular or a more or less vascular lesion The ab ence of vessels or the presence of an abnormal vessel will probably also be reflected in the regional cerebral blood flow (rCBF) Some of the main changes in regional cerebral blood flow in cases with cerebral tumours have been reported in previous communications in which both general and local changes in flow were described (CRONQVIST et coll 1965 1966) Similar changes have recently been reported also in focal cerebral vascular di orders (CRONQVIST & LAROCHE 1967) A local increase in flow was found to correspond to angiographic findings of partly the same type as encountered in tumours and this raised the question as to an eventual similarity in the pathology of cerebral lesions of different kinds The results from a combined study of measurements of the regional cerebral blood flow and cerebral angiography in 39 cases of intracranial tumours will now be presented The aim of the investigation was to determine

1 The influence of the intracranial tumours on the overall cerebral blood flow

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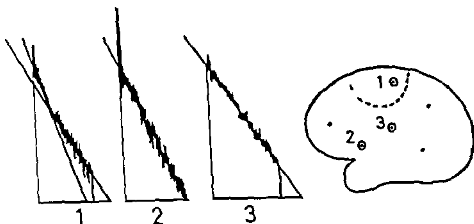


Fig 1 Initial part of clearance curves written in semilogarithmical form against time Curves obtained over tumour tissue (1) carotid siphon (2) and over non tumour tissue (3)

assumption that in a normal subject a ^{133}Xe clearance curve of the cerebral region is made up of a sum of two mono-exponential functions representing a fast and a slow type of flow probably corresponding to those in the grey and the white matter respectively The solubility of the gas in the blood and the respective tissue in these two kinds of brain tissue is different and different partition coefficients (lambda) have to be used for the flow calculations Pathologically changed tissue like tumour tissue may be assumed to have other physio-chemical characteristics than normal grey and white matter so that another partition coefficient should be used to calculate the flow in such tissue The lambda for tumour tissue is however not known and furthermore will probably vary Lambda values for normal tissue have therefore been used in the present study which means that an error has been introduced into the calculation of tumour tissue flow The reported values will have to be regarded as being relative

The normal flow values upon which this study is based are as follows (INGVAR CRONQVIST EKBERG et coll 1965)

Fast flow (f_g) $=79.7 \pm$ SD 10 7 ml/100 g/min
Slow flow (s_w) $=20.9 \pm$ SD 2 6 ml/100 g/min
Mean flow (m) $=49.7 \pm$ SD 5 6 ml/100 g/min

The computer program mentioned above also gives a mean flow value (mean^{1}) calculated from isotope clearance for 10 minutes according to the stochastic method (HOEDT RASMUSSEN SVEINSDOTTIR & LASSEN 1966) The mean 10-min value is 49 8 ± SD 5 4 ml/100 g/min

2 The regional blood flow (rCBF) within the tumour tissue per se as well as in relation to flow in surrounding non tumour tissue

3 The correlation of regional flow studies with cerebral angiography

4 The effect of increased intracranial pressure on the rCBF

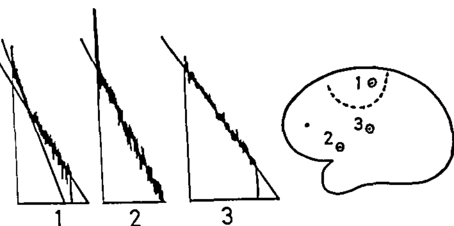
5 The value of rCBF measurement in the diagnosis of cerebral tumours varying in nature

Material The series consisted of 39 cases of supratentorial tumours Four were extra cerebral (meningiomas) and 35 intra cerebral, ten of which were of metastatic origin In 32 of the 39 cases the diagnosis was confirmed by biopsy, no biopsy was made in cases of radiographically and clinically established deep seated lesions All cases were examined by routine carotid angiography, in conjunction with which a rCBF study was performed, bilateral studies were carried out in two cases The presence of increased intracranial pressure was determined by funduscopic examination and, in addition, in nine cases by direct measurement of the intraventricular pressure by means of a polythene catheter placed in the lateral ventricles (LUNDBERG 1960) The localization and the extent of the tumour as well as the presence or absence of pathologic vessels and arteriovenous shunts were determined radiographically

Methods The carotid angiography preceded the rCBF measurement in all cases Methylglucamine diatrizoate (Urografin 60 %) was used as contrast medium a total volume of about 20 ml being injected into the internal carotid artery Films were obtained at 14 second intervals for the lateral and 8 second intervals for the a p serials Multiple simultaneous measurements of the rCBF were made according to the ^{133}Xe clearance technique devised by LASSEN et coll 1963 Four or eight extracranial scintillation detectors, placed at right angles to the sagittal plane of the skull and adjusted to cover abnormalities in the preceding angiograms, were employed Following the rCBF study the central axis of the detectors was marked by small lead indicators on the head of the subject and a lateral film was obtained to relate the field of the detectors to the angiogram

Repeat samples of arterial blood were taken for the determination of haematocrit values and the arterial carbon dioxide tension (aPCO) during the rCBF study The pulse rate and the arterial blood pressure were also measured Details of the technical and mathematical aspects of the rCBF method were described at the symposium on regional cerebral blood flow at Lund in 1965 as well as by HØEDT RASMUSSEN (1967)

Calculation of the flow values were all made by a computer program developed by HØEDT RASMUSSEN, SVEINSDOTTIR & LASSEN (1966) This is based upon the



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The computer program mentioned above also gives a mean flow value (mean$^{10\,m}$) calculated from isotope clearance for 10 minutes according to the stochastic method (HOEDT RASMUSSEN SVEINSDOTTIR & LASSEN 1966) The mean 10-min value is $49\,8 \pm$ SD 5 4 ml/100 g/min

Table 1

Cerebral blood flow in cerebral tumours and general effects

	Fast flow ml/100 g/min	Slow flow	Mean flow	aPCO²
Normals (n = 7)	79 7	20 9	49 7	38 6
Tumours (n = 39)	57 7	18 2	33 5	36 7
Percentage decrease	27 6 %	12 5 %	32 6 %	—

Table 2

Cerebral blood flow in tumours and focal effects

	Tumour flow	Non tumour flow	T/non T flow
Tumour flow non tumour flow (n = 23)	73 2	50 0	147
Non tumour flow tumour flow (n = 13)	53 3	63 4	84
Total (n = 36)	68 5	55 3	124

Results

Form of the xenon 133 clearance curve A clearance curve from a normal case, as well as curves obtained over regions of normal brain tissue display characteristic features (Fig 1) When the bolus of the isotope arrives in the field of the detector, a sharp initial rise is followed by a smooth fall in the beginning fairly steep but gradually less so and reaching the baseline in about 15 to 20 minutes A brief initial flattening a plateau, is sometimes noted before the beginning of the downward slope (cf HOEDT RASMUSSEN 1967) The curves in this study often differed from this normal appearance An initial peak of different height and of different, usually short, duration was often encountered during the very first part of the curve, rising at a varying height above the point of the start of the slope (Fig 1) This finding suggested that in the tumour group in addition to the normal fast and slow components, there was also a third one which represented a compartment with a flow higher than in the grey matter

1 General changes in the cerebral blood flow The hemispheric flow values for the whole series was f_g=57 7 f =18 2 mean =33 5, and mean[10]=38 6 ml 100 g/min The values have been calculated as the mean for all regions measured It may be seen from Table 1 that these values are low compared to normal values i e the presence of a tumour causes a general decrease in the cerebral blood flow

Table 3

Cerebral blood flow in cerebral tumours and flow related to angiographic changes

		Flow ml/100 g/minute		
Angiography	n	Total hemisphere	Tumour	Non tumour
1 Abnormal vessels + a v shunts	19	59 4	74 5	53 1
2 Abnormal vessels	6	51 9	53 9	52 2
3 Avascular	11	59 3	59 4	59 0
	8	57 8	49 1	60 2
	3	63 1	79 7	55 7

within the affected hemisphere The decrease is most marked for mean° and f_g flow 32 6 % and 27 6 % respectively and less marked for f_w (12 5 %) The mean 10 min value was much less decreased than the value for mean 22 5 % and 32 6 % respectively

Important variations in flow between the individual cases were recorded A significant decrease i e a fast flow less than 58 3 ml/100 g/min (79 7—2×SD) was noted in the majority of 22 cases — a significant increase viz above 101 ml/100 g min in two cases a non significant decrease was evident in fifteen cases Cases with and without significant flow changes did not differ from the angiographic point of view in both groups pathologic vessels and shunts as well as increased intracranial pressure were present

Table 1 shows that variations in the arterial PCO existed (mean value 36 7) but were generally not excessive although the above mentioned flow values are uncorrected for PCO the general conclusions are not invalidated

2 *rCBF in tumour and non tumour tissue* In this comparison between the rCBF in tumour and non tumour regions three cases were discarded because of the difficulty in assessing the site of the lesion and its relationship to the rCBF detectors

The fast flow measurements (rCBF) from the region or the regions corresponding to or immediately adjacent to tumour tissue (T) as indicated by angiography were compared with measurements for non tumour tissue (N/T) (Table 2)

The flow in the tumour tissue for the entire group was found to exceed that of the surrounding normal tissue The difference was mainly manifested in the fast flow the average being 68 5 and 55 5 ml/100 g/min for the respective tissues Expressed as a percentage of non tumour flow the flow in tumour tissue was 124 %

Table 1

Cerebral blood flow in cerebral tumours and general effects

	Fast flow ml/100 g/min	Slow flow	Mean flow	aPCO2
Normals (n = 7)	79.7	20.9	49.7	38.6
Tumours (n = 39)	57.7	18.2	33.5	36.7
Percentage decrease	27.6%	12.5%	32.6%	—

Table 2

Cerebral blood flow in tumours and focal effects

	Tumour flow	Non tumour flow	T/non T flow
Tumour flow > non tumour flow (n = 23)	73.2	50.0	147
Non tumour flow > tumour flow (n = 13)	53.3	63.4	84
Total (n = 36)	68.5	55.3	124

Results

Form of the xenon 133 clearance curve. A clearance curve from a normal case, as well as curves obtained over regions of normal brain tissue display characteristic features (Fig. 1). When the bolus of the isotope arrives in the field of the detector, a sharp initial rise is followed by a smooth fall: in the beginning fairly steep but gradually less so, and reaching the baseline in about 15 to 20 minutes. A brief initial flattening, a plateau, is sometimes noted before the beginning of the downward slope (cf. Hoedt-Rasmussen 1967). The curves in this study often differed from this normal appearance. An initial peak of different height and of different, usually short, duration was often encountered during the very first part of the curve, rising at a varying height above the point of the start of the slope (Fig. 1). This finding suggested that in the tumour group in addition to the normal fast and slow components, there was also a third one which represented a compartment with a flow higher than in the grey matter.

1. General changes in the cerebral blood flow. The hemispheric flow values for the whole series was f_g=57.7, f_w=18.2, mean=33.5 and mean[10]=38.6 ml/100 g/min. The values have been calculated as the mean for all regions measured. It may be seen from Table 1 that these values are low compared to normal values, i.e. the presence of a tumour causes a general decrease in the cerebral blood flow

aemia within the avascular region thus occurred in three cases These high values influenced the hemispheric values and explained the fact that for the whole group no difference was present between the flow in the lesion and that in other regions Excluding these three cases the average values for the flow in the avascular tumour and in the non tumour tissue were 49 1 and 60 2 ml/100 g/min respectively i e a substantial decrease within the tumour was evident

4 *The intra cranial pressure and the rCBF pattern* Increased intracranial pressure was present in eighteen of the 39 cases studied It was always indicated by papilledema and in nine cases further verified by continuous recording of the intraventricular pressure

No significant difference was evident in the present series in the average flow at high (16 cases) or normal (21 cases) intracranial pressure neither in lesion tissue nor in non lesion tissue

5 *Difference in rCBF pattern between cerebral tumours of different types* Too few cases of meningeoma or astrocytoma were contained in the series to warrant valid conclusions concerning the difference in flow in different kinds of tumour The authors have therefore refrained from such an evaluation in the present material

Discussion

Appearance of clearance curve A specific change in the first part of the clearance curve the so-called initial peak has been described PAULSON et coll (1967) in a recent publication have stated that this initial peak may be of two kinds The initial part of the clearance curve is plotted in semi logarithmic form against the time obtained over the tumour over the carotid siphon and over normal tissue respectively in Fig 1

A sharp rise corresponding to the injection of the isotope followed by a linear fall in activity are normally present A peak over the carotid siphon rises high above the point from which the linear fall starts This peak is a sign of a rapid transportation of the bolus of the isotope through the field of the detector in this instance through the carotid artery Such a peak will of course also occur whenever the possibilities for abnormal rapid isotope transportation exist i e in arteriovenous malformations (HAGGENDAHL et coll 1964) and arterio enous shunts (CRONQVIST & LAROCHE 1967) The authors have termed this a carotid or shunt peak

Not only a shunt peak but also a peak of longer duration may be present in the curve obtained over tumour tissue This indicates that in addition to the normal two components of the clearance curve there is a third that signifies a very rapid

Variations in tumour flow occurred however in the individual cases and based upon these variations the cases were separated into two groups There were thus *thirteen cases with a low flow* in tumour tissue and twenty three with a high tumour flow, in two of the latter cases even exceeding normal values

The respective clearance curves in cases with a high tumour flow often demonstrated the specific change described under the appearances of the curves i e *an initial peak indicating the presence of an initial third component A local* high fast flow was sometimes present without the corresponding curve possessing any obvious peak *A peak was sometimes also evident in cases with a low* tumour flow

When comparing peak curves with flow values obtained for mean[c] and mean[10] the last mentioned was almost constantly higher, i e it was possible to tell the presence of a peak from these measurements alone This fact will be more extensively dealt with in the discussion

3 *Comparison between angiographic findings and rCBF measurements* The cases were separated into three groups according to the pathologic changes observed Twenty two cases formed the first group, these having pathologic vessels and arteriovenous shunts The second group consisted of six cases with only pathologic vessels and the third and last group was made up of eleven cases without pathologic vessels and arteriovenous shunts, i e avascular tumours (Table 3)

The average fast flow values, hemispheric values in these three groups were 59 4 51 9 and 59 3 ml *100* g/min respectively *A marked decrease in flow was* thus present in all groups and this was most evident when pathologic vessels were *the only findings*

Local changes were also encountered In cases with arteriovenous shunts and pathologic vessels at angiography the *flow* in the region with these focal abnormalities was in all but two found to be high while the flow in other regions was markedly reduced, 74 5 and 53 1 ml 100 g min respectively Relative hyperaemia within the abnormal region was thus present in these cases

In the second group, with pathologic vessels as the only findings, the flow was decreased to about the same level in both the lesion region and in the non lesion region Variations were however present in the individual cases, thus three had a high local flow over the lesion and three a low local flow

In the eleven cases with an avascular lesion registered angiographically a decrease in flow over the lesion would have been *likely For the whole group, how*ever, the average flow values in the avascular zone and in the tissue outside it did not differ and were *recorded at 58 4 and 59 0 ml/100 g/min*, respectively Individual changes were also noted in this group of cases Marked relative hyper

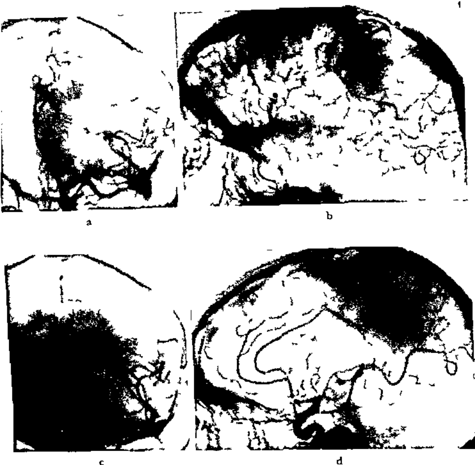


Fig 3 From a case of intracerebral ha morrhage a) Acute phase Marked sh ft of pericallosal artery medial displacement of the Syl ian vessels b) Abundance of early filling veins in f ontoparietal region c) After partial reco ery less expansivity d) No early f lling veins

normal This observation is in accord with earlier reports that a focal lesion may cau e a general reduction in the cerebral blood flow (KETY et coll 1948 HØEDT RASMUSSEN & SKINHØJ 1965) Remote effects of a focal lesion have also been described in cases of a lesion in the brain stem (INGVAR et coll 1964 CRONQVIST 1967)

Increased intracranial pressure has been reported to decrease the cerebral blood flow No difference in flow in cases with and without increased intracranial pressure was however apparent in this series The general decrease noted cannot

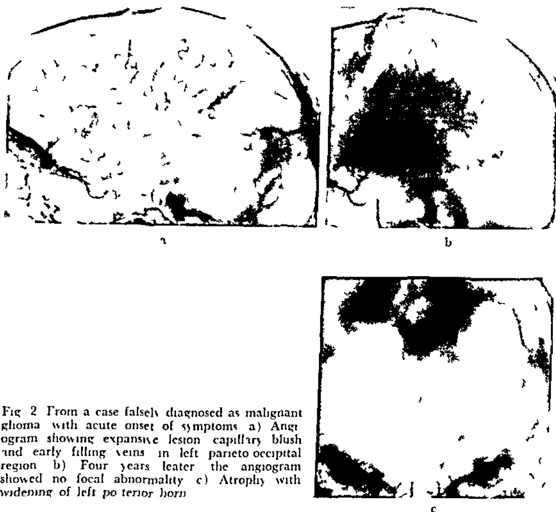


Fig 2 From a case falsely diagnosed as malignant glioma with acute onset of symptoms a) Angiogram showing expansive lesion capillary blush and early filling veins in left parieto occipital region b) Four years leater the angiogram showed no focal abnormality c) Atrophy with widening of left posterior horn

flow The authors have termed this a tissue peak An initial peak most often occurred in curves over tissues with angiographically demonstrated arteriovenous shunts The analysis of these curves disclosed fast flow values

The observation that flow values for mean^{5} and mean^{10} derived *from peak* curves presented a difference exceeding the normal of ± 6 ml 100 g min can be theoretically explained Although the finding may be of practical value it must be stressed that the above mentioned difference is not constant and thus not a reliable sign of a peak This is due to the fact that evaluation of the height of the curve necessary for calculation of the mean flow values, is sometimes difficult

The results indicate that a tumour usually induces a general reduction in the blood flow in the hemisphere involved This reduction is also recorded on the contralateral side i e in regions that angiographically and clinically appear

indicate the presence of regional anoxia and to be secondary to loss of normal vasomotor regulation (HOEDT RASMUSSEN et coll 1967) LASSEN (1966) recently summarized the evidence that local hyperaemia of this type may be ascribed to tissue acidosis following cerebral tissue hypoxia or anoxia

Abnormal connections between cerebral arteries and veins constitute an important feature in the pathologic description of malignant cerebral tumours, and indeed seem to explain the initial peak in some rCBF curves as well as the local hyperaemia It is however a tempting hypothesis that the presence of rapidly perfused regions may sometimes be secondary to anoxia caused by the neoplasm If this be so the areas with secondary hyperaemia would probably be located mainly in the border zone between tumour and non tumour tissue The employment of an increased number of smaller detectors has indicated that in some tumour cases this may really be true (PAULSSON et coll 1967)

Acknowledgement

This study was supported by grants from Riksforeningen mot Cancer The authors are indebted to D H Ingvar who placed the multiple channel detector equipment at our disposal The equipment was donated by the Wallenberg Foundation

SUMMARY

The results of a combined study with measurement of the regional cerebral blood flow and cerebral angiography in 39 cases of supratentorial tumours are presented Seven of the cases were confirmed by biopsy

ZUSAMMENFASSUNG

Die Ergebnisse einer kombinierten Studie mit Messung des regionalen cerebralen Blutstroms und cerebraler Angiographie von 39 Fallen von supratentorialen Tumoren werden vorgelegt Sieben der Falle wurden bei Biopsie bestatigt

RÉSUMÉ

Les auteurs presentent les resultats d une etude combinée de mesures du débit sanguin cérébral regional et d angiographie cerebrale dans 39 cas de tumeur sus tentorielle Sept de ces cas ont ete confirmes par biopsie

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therefore have been caused by pressure alone but must have been due to other secondary effects of the lesion

That intracranial pressure may influence cerebral flow has been demonstrated in animal experiments by SVETNOV, KALLQVIST & SIESJO 1967 The same effect has been found to be present in man (CRONQVIST, INGVAR & LASSEN 1966) in cases with spontaneously appearing periods of increased intracranial pressure, so called plateau waves (LUNDBERG 1960) A preliminary report (LUNDBERG, CRONQVIST & KALLQVIST) on the relation between cerebral blood flow, angiography and these plateau waves has been published A more extensive study of the relation between cerebral blood flow and increased intracranial pressure is under way (CRONQVIST & LUNDBERG)

The present results have further indicated that the flow in tumour tissue as compared to normal flow is changed The lesion flow in some cases mainly of avascular tumours, was lower than in the rest of the hemisphere In other cases no marked difference in flow between lesion and non lesion tissue was evident Most cases, however, had a high flow, a relative hyperaemia within the tumour region In many of the cases, i e 18 out of 39 cases, such a hyperaemia coincided with the angiographically demonstrated region with arteriovenous shunts and pathologic arteries It is of specific interest that local relative hyperaemia and initial peaks were present also in cases in which no shunts were evident at angiography, that is in tumours with only pathologic vessels and even in those that angiographically appeared avascular The rCBF technique thus permitted the registration of arteriovenous shunts in spite of no other evidence of their presence

It was stressed in previous communications (CRONQVIST 1966, 1967 and CRONQVIST & LAROCHE 1967) that diagnostic problems of differentiation between a cerebral vascular lesion and a malignant tumour may be encountered The basis for these difficulties is the appearance of local hyperaemia and early filling veins in both these lesions (CRONQVIST & LAROCHE 1967) The findings in an expansive lesion with an abundance of early filling veins in relation to the lesion are demonstrated in Fig 2 The study was made in the acute stage of the disease Angiographically the changes could well tally with those of a large malignant tumour although the clinical signs were in favour of intracerebral bleeding A repeat investigation after clinical improvement indicated regression of the expansivity and no abnormal filling of veins The observation that the abnormal venous filling in vascular disorders is a transitory phenomenon can be utilized for differential diagnostic purposes A repeat study in malignant tumours will thus disclose persisting or more often an increase in abnormal veins This is in contrast to a cerebrovascular lesion for which the conditions will probably have returned to normal

Focal relative hyperaemia in cases of cerebral vascular lesions has been said to

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EFFECT OF ANGIOTENSIN ON THE DOG KIDNEY

by

ELEONORA HOTOVY ANDRAS LOSONCI and JANOS LAKOS

The authors have previously investigated the physiologic functions by serial nephroangiography in young patients with essential hypertension (HOTOVY et coll 1968) It was considered that endogen angiotensin may also have played a role in the pathogenesis of hypertension In view of the fact that little work on this subject appears to have been done it was decided to investigate the effect of angiotensin on the hemodynamics and function of the kidney in dogs

Materials and Methods Transfemoral aortography was carried out in fifteen mongrel dogs weighing 10 to 25 kg under intravenous chloralose anesthesia in a dose of 100 mg kg bodyweight The contrast medium 0.5 ml/kg bodyweight Uromiro 75 % was injected with a Gidlund injector under a pressure of 4 kg/cm into the aorta close to the origins of the renal arteries The injector was coupled to an Odelca film changer and 12 films were exposed during the first 5 seconds further films were produced at the standardized times of 10 15 20 30 60 90 120 150 and 180 seconds The exact chronologic order of the films was recorded on an Elema Mingograph (HOTOVY et coll) The mean arterial pressure was measured with a Hg manometer inserted into the femoral artery of the other side

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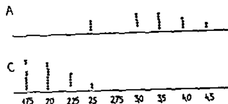


Fig 3 Time of disappearance (seconds) of the great renal arteries in the controls (C) and in the angiotensin study (A) Each point refers to one kidney

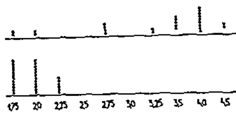


Fig 4 Time of disappearance (seconds) of the arborization in the controls (C) and in the angiotensin study (A) Each point refers to one kidney

seconds (group A Fig 1) The advent of the medium in the arterial arborization in three of the dogs occurred at the normal time while in the remaining dogs the appearance time was longer 1 25 to 3 5 seconds (group A Fig 2)

The medium was late in disappearing from the main arteries (over 2 5 to 4.5 seconds) with the exception of both kidneys in two dogs and the left kidney in one dog (group A Fig 3) The disappearance time of the medium in the arterial arborization was also constantly late over 2 5 to 4 5 seconds except in two dogs (group A Fig 4) A transient spasm was observed in the renal artery of one of the kidneys in two dogs

Three types of nephrographic and postnephrographic pyelographic phenomena were identified

1 In the majority of the dogs, nine dogs the early nephrographic effect was either poor or absent and differentiation did not take place The complete nephrographic effect was extremely late in occurring The postnephrographic pyelogram appeared late or had not appeared at 3 minutes after injection

2 In two dogs in which the appearance and disappearance times in the arterial system were equally late the early nephrographic effect was good well differentiated and not delayed The complete nephrographic effect was een at the correct time but persisted longer The postnephrographic effect had not appeared at 3 minutes

3 In two dogs in which the appearance and disappearance times in the arterial system were the same as in the controls the nephrographic phenomena both from the point of view of duration and quality were similar to the controls Filling of the pelvis was however delayed

In two dogs it was observed that the different types of nephrographic phenomena described occurred in one and the same kidney e g the second type in the upper pole of the left kidney in one dog while in the remainder of the same kidney the first type appeared

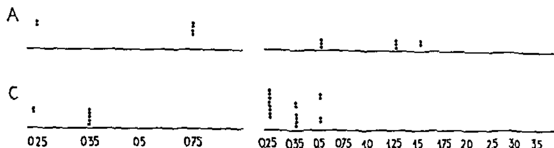


Fig 1 Time of appearance (seconds) of the great renal arteries in the controls (C) and in the angiotensin study (A) Each point refers to one kidney

Fig 2 Time of appearance (seconds) of the arborization in the controls (C) and in the angiotensin study (A) Each point refers to one kidney

Angiotensin (Hypertensin Ciba) was administered in doses of 0 0025 to 0 005 μg/kg into the aorta through the catheter In ten dogs, an initial control nephroangiogram was followed after an interval of 60 minutes by the administration of angiotensin, and after a further 60 second interval the second series of serial nephroangiograms was obtained In the remaining five dogs, the series of nephroangiograms with angiotensin was first carried out, and after an interval of 60 minutes the control series was obtained

Results

Control studies The contrast medium appeared in the main branches of the renal arteries within 0 25 to 0 35 seconds and in the intrarenal arterial arborization within 0 25 to 0 5 seconds after its injection (group C, *Figs 1 and 2*) The contrast medium disappeared from the renal arterial system within 1 75 to 2 25 seconds (group C, Figs 3 and 4) The early nephrographic phase appeared within 0 35 to 1 0 seconds and was followed by a differentiation of the cortex, the septum (columna Bertini) and the medulla The complete nephrogram reached maximum density in 3 to 4 seconds, persisted for 15 to 20 seconds and then became less evident The great veins appeared within 10 to 15 seconds The postnephrographic pyelographic phase became visible in 1 0 to 1 5 minutes after injection of the contrast medium

Angiotensin effect The contrast medium appeared in the main branches of the renal arteries in both kidneys of seven dogs and in the right kidney of one dog at the normal time In seven other dogs in both kidneys and in one dog in the left kidney the contrast medium appeared late in the main arteries, at 0 5 to 0 75

schiedenen Gefassbezirken selbst in der einzelnen Niere hervorrufen kann Die Studie scheint auch darauf zu deuten dass das Angiotensin direkt auf die renalen Tubuli wirkt

RÉSUMÉ

Les auteurs ont etudie l effet de l angiotensine sur le rein du chien au moyen de néphroangiographie en série Les résultats ont montre que l angiotensine peut produire une vasoconstriction dans differents territoires ou dans un seul et m me rein Cette expérimentation conduit aussi a penser que l angiotensine agit directement sur les tubules renaux

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Discussion

Angiotensin produces vasoconstriction of different areas of the kidneys which can be well illustrated radiologically The vasoconstriction of the main arteries presents itself in the lateness of the filling of this area, while the constriction of the interlobular arteries manifests itself in the prolongation of the disappearance time in the main arteries The angiotensin brought about a circumscript and transient spasm in one of the main renal arteries in two dogs

The increase in the peripheral resistance depends on the site of the vasoconstriction and may be of two types In the first, in which it is preglomerular, the nephrographic effect is poor or absent and differentiation does not take place With an increase in the postglomerular resistance the arborization is rich and the filling of the arteries is marked In addition, though the disappearance time of the medium is prolonged, the nephrographic effect is normal in time and intensity and well differentiated

The postnephrographic filling of the pelvis may be late or absent even at 3 minutes The fact that the pelvic filling was late in all the cases after angiotensin may be due to a direct tubular effect of the drug (EISALO & RASANEN 1963 LEYSSAC 1965)

All these effects were brought about by such a small dose of angiotensin that, although above the physiologic dose for normotensive dogs it could not have reached a pharmacologic dose (ASTOIN 1965) and could not have increased the systemic blood pressure

The facts that the angiotensin given in the applied dose acts differently in different dogs, as well as in both kidneys of one and the same dog, and, what is more, acts differently in one and the same kidney suggest that factors as yet unknown may play a role

Acknowledgement

The technical assistance of I Bartfai L Diviki J Conczol and Gy Nagy is gratefully acknowledged

SUMMARY

The effect of angiotensin on the dog kidney was investigated by means of serial nephroangiography The results indicated that vasoconstriction may be produced by the drug in different areas of even one and the same kidney The study also seemed to suggest that angiotensin acts directly upon the renal tubules

ZUSAMMENFASSUNG

Der Einfluss von Angiotensin auf die Hundenniere wurde mit Serien Nephroangiographie studiert Die Resultate zeigten dass diese Droge eine lokal begrenzte Kontraktion in ver

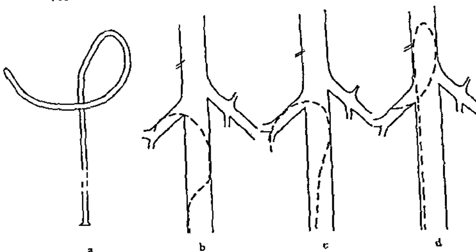


Fig 1 a) New type of polythene catheter for catheterizat on of the left (and also often the right) adrenal vein b) Catheter introduced into the caval vein with tip in right r nal vein c) Guide stiffening of the stem of the catheter when it is pushed further up the ca al vein d) Loop reformed

method of catheterizing the left adrenal vein for retrograde phlebography and in 1964 demonstrated an aldosterone producing adenoma (which was also evident at aortography) The present author has later catheterized the right adrenal vein as described in a previous paper in which the vein anatomy was briefly considered Two cases from our present material are described separately in thi paper

Technique Catheterization of the right adrenal vein *is performed* mainly as described previously (1967) For the left side the yellow radiopaque catheter has been replaced by a non-opaque polythene catheter No 240 which ends in a large loop of a shape similar to the Greek letter φ (*Fig 1*) *This type* of catheter has been used in ten cases It is more pliable in the vessels than the other cath eter so that it is often easier to adapt to the adrenal vein and the sampling of the blood and the injection of contrast *medium tend* to be more complete

The catheter *is inserted* via *the right femoral vein* with a Seldinger guide No 203 The tip of the catheter is turned in a retrograde direction in the caval vein by introducing it into a renal vein *the* loop appearing when the stem of the catheter is pushed further up the caval vein It is sometimes necessary to stiffen the catheter temporarily with the guide during this manoeuvre After turning

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EPINEPHRO-PHLEBOGRAPHY IN TWO CASES OF CONN'S SYNDROME

by

C G MIKAELSSON

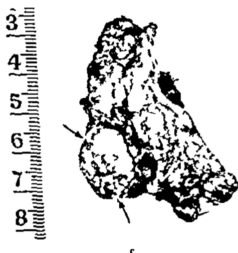
This condition is characterized by more or less grave hypertension without oedema and with hyperaldosteronism in combination with depression of the plasma renin activity (CONN 1964) There are often changes in the electrolyte balance such as hypokalaemic alcalosis with complaints of muscle weakness and *polydipsia Many cases have lasted for decades while others have had a short* duration of one or a few years The disorder is caused by an aldosterone producing adreno-cortical adenoma in the zona fasciculata or glomerulosa Clinical and laboratory investigations occasionally fail to afford the correct diagnosis and *the radiologic demonstration of a tumour is therefore valuable, apart from* the importance of localizing the side for operation As the tumours are often small and impossible to demonstrate with the usual methods, an investigation was made of the possible role of retrograde phlebography in arriving at a diagnosis

A few authors have *reported catheterization of both adrenal* veins for hormone analysis (MASONI 1957 BETTE et coll 1964) LEVY et coll (1961) has employed retrograde phlebography but no informative roentgenograms of the adrenal veins were published and no tumours were demonstrated *BUCHT (1962) described* a

Submitted for publication 24 October 1967

a

b



c

Fig 3 Case I a) Left nephroangiography Adrenal artery with normal branches no visible tumour b) Left epinephro-phlebography Rounded lesion 1? mm in diameter displacing the adrenal veins and probably the diaphragmatic vein (arrows) c) Specimen

The technique in all other respects is the same as before except that Urografin 76 % is now used as contrast medium The small vessels are better outlined with this medium No damage by the catheter to the small vessels or any other complications have been encountered with the new technique



Fig 2 Roentgenograms of two normal adrenal glands

the tip is directed to the left and pulled into the left renal vein It will there be pressed against the cranial part of the wall, where the adrenodiaphragmatic truncus opens close to the left aspect of the spine The tip usually passes directly into the truncus, but sometimes the catheter will have to be replaced by one of modified form At times it may be possible to introduce the tip into the adrenal vein proper, which issues into the truncus to the left of the diaphragmatic vein This is not essential but gives the best result Any advance of the tip into the diaphragmatic tributary must be avoided, however, and should this occur the tip must be retracted into the truncus —This type of catheter is often used also for the right adrenal vein —When the examination is completed, and the catheter is to be withdrawn, the tip should be pulled out of the adrenal vein, and the loop straightened with the guide which is easily performed This manoeuvre is also advisable for the right adrenal vein, as described in the earlier paper



a b

c

Fig 3 Case 1 a) Left nephroangiography Adrenal artery with normal branches *no* visible tumour b) Left epinephro-phlebography Rounded lesion 12 mm in diameter displacing the adrenal veins and probably the diaphragmatic vein (arrows) c) Specimen

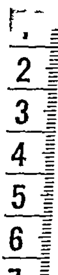
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a



b



c

Fig 4 Case 2 a) Left epinephro phlebography Rounded lesion 11 mm in diameter lying caudally in the gland and displacing the surrounding adrenal veins (arrows) no vessels evident in the tumour itself b) Phlebography of specimen c) Specimen from behind

Case reports

Case 1 Female aged 51 with hypertension for 4 years The blood pressure was about 260/140 mm Hg without therapy and slightly less with treatment The patient was found to have primary hyperaldosteronism with considerable renal damage

Conventional roentgen examinations afforded little information Urography and abdominal

aortography were both negative. On the left side an adrenal artery arose from the left renal artery and at selective nephroangiography this artery together with several smaller supply arteries covering a fairly large area were well filled (Fig. 3a). No appropriate diagnosis could be made, however.

The roentgenograms obtained at epinephro-phlebography revealed a poorly vascularized small lesion 12 mm in diameter displacing the intraglandular veins in the central and medial part of the gland and probably the diaphragmatic vein close to it (Fig. 3b). This change occurred early in the series and due to lack of experience the small but quite characteristic changes were overlooked before operation. The left adrenal gland was removed and found to contain a typical Conn's tumour, a yellowish cortical adenoma with cell polymorphism and compression but no infiltration (Fig. 3c).

The aldosterone excretion and the plasma electrolytes became normal and the blood pressure decreased from 210/120 in the first to 150/[illegible] in the second week. Three months later it had become stabilized around 175/110. The muscle weakness disappeared and the general condition of the patient improved; the incomplete recovery was probably due to the associated renal damage.

Case 2. Female, aged [illegible], with migraine from childhood. After transient hypertension at pregnancies the blood pressure had been about 230/130 for a year. The patient had hyperaldosteronism with a urinary excretion of [illegible] μg aldosterone/24 hours (during salt starvation) and marked hypokalemic alcalosis. Further examinations of the electrolyte-aldosterone balance indicated primary hyperaldosteronism.

Urography and lumbar aortography were negative. (Aortography was also performed after injection of 10 μg epinephrine to cause small vessels other than the adrenal arteries to contract.) A round lesion [illegible] mm in diameter was evident at epinephro-phlebography. This was displacing the intraglandular veins in the caudal extremity of the left adrenal gland; no vessels were observed in the tumour itself (Fig. 4a).

The operation via the retroperitoneal route exposed the adrenal gland in its caudal, dorsal and cranial aspects. A tumour present caudally was removed (Fig. 4, b and c). After the operation the potassium values in the plasma rose from [illegible] to [illegible] mEq/l and the aldosterone excretion became normal. During only two weeks follow-up the blood pressure decreased to 1[illegible]0/100.

The examinations in these two cases have proved that it is possible by means of epinephro-phlebography to discover small adenomas in the adrenal glands. Such growths can hardly be detected by arterial angiography or by retroperitoneal pneumography.

SUMMARY

Two small adrenal tumours were demonstrated by selective retrograde phlebography of the adrenal vein. The technique is described in detail.

ZUSAMMENFASSUNG

Zwei kleine Tumoren der Nebenniere konnten mit Hilfe selektiver retrograden Phlebographie der suprarenalen Vene demonstriert werden. Die Technik wird eingehend beschrieben.

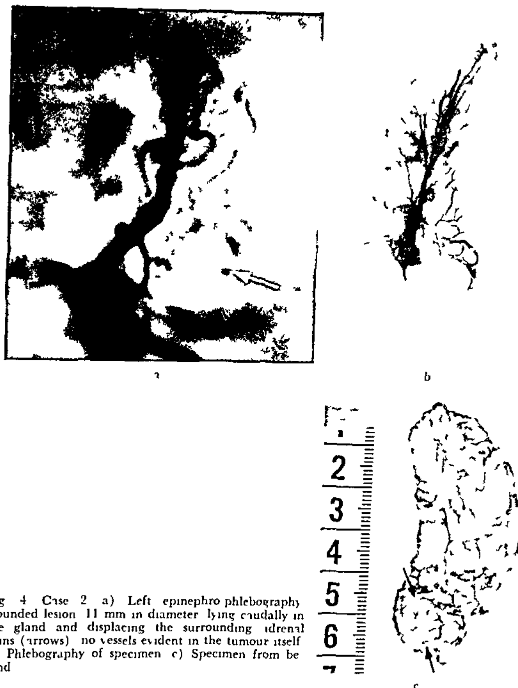


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FROM THE DEPARTMENTS OF PATHOLOGY II (DIRECTOR PROF S FALKMER), DIAGNOSTIC RADIOLOGY (DIRECTOR PROF G F SALTZMAN) AND SURGERY (DIRECTOR PROF S BORGSTROM) UNIVERSITY OF UMEA, SWEDEN

HAMARTOMA (LIPOANGIOMYOMA) OF THE KIDNEY

by

S FALKMER P JUNGHAGEN O RAIS and G F SALTZMAN

Large benign renal tumours of mixed mesenchymal origin so-called angiomyolipomas are fairly uncommon although they are known to occur in 40 to 80 per cent of patients with tuberous sclerosis (ESSEX 1966) KLAPPROTH, POUTASSE & HAZARD (1959) found only fifteen reported cases unassociated with tuberous sclerosis and added four of their own Angiomyolipomas are generally considered to be hamartomas and thus do not represent true neoplasms (KLAPPROTH et coll) Apart from symptoms evoked by the tumour mass per se and by interference with its vascular supply so-called angiomyolipomas of the kidney are mainly asymptomatic and are mostly discovered incidentally at autopsy (JENSEN & PETERSEN 1960 ESSEX 1966)

Being non neoplastic and mainly asymptomatic the major clinical importance of renal angiomyolipomas is that they may be erroneously diagnosed as renal carcinomas or Wilms's tumour (KAY PRATT & SALZBERG 1966) Such a misinterpretation is particularly liable to occur when the tumour suddenly becomes partly necrotic and gives marked clinical signs Some of the difficulties inherent in the pre-operative diagnosis of large hamartomas of the kidney will be reviewed against the background of an illustrative case

Submitted for publication [illegible] October 1967

RÉSUMÉ

Dans deux cas de syndrome de Conn la phlebographie selective rétrograde de la veine surrénale a montré une petite tumeur surrénale La technique est décrite en détail

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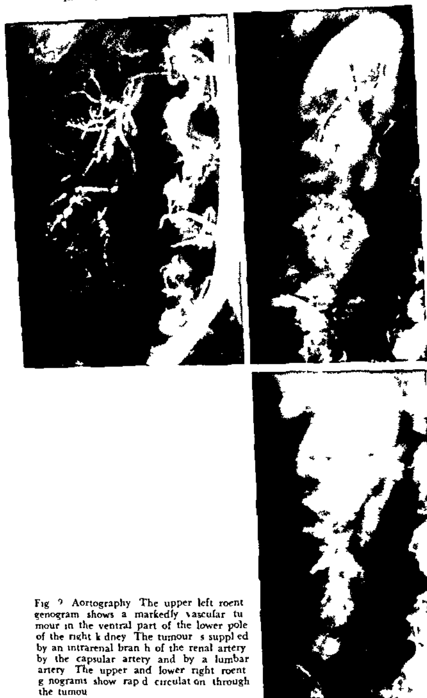


Fig 9 Aortography The upper left roentgenogram shows a markedly vascular tumour in the ventral part of the lower pole of the right kidney The tumour is supplied by an intrarenal branch of the renal artery by the capsular artery and by a lumbar artery The upper and lower right roentgenograms show rapid circulation through the tumour



Fig 1 Urography No obvious deformity of the right renal pelvis

Case report

A 21 year old woman previously well and without signs or history of tuberous sclerosis gave birth to a normal child the pregnancy and the delivery also being normal Six days post partum the rectal temperature slowly rose to reach a maximum of 39.8 C twelve days later At that time a palpable mass the size of a fist was noted over the right kidney and subhepatic regions About three weeks after delivery the erythrocyte sedimentation rate was 158 mm/hr A moderate anemia was noted with a haemoglobin content of 8.5 g/100 ml The activity of several iso enzymes of the blood was markedly and consistently elevated the serum lactic acid dehydrogenase activity being 540 units the HBD 450 units and the ratio between SGOT and SGPT 160/220 Serum electrophoresis lowered albumin content and an elevated concentration of α and β globulins The urine was normal

Urography No obvious change in the shape of the right kidney and no deformity of the renal pelvis (Fig 1) It was noted however that the right kidney was fairly easily movable

Abdominal aortography (Fig 2) A markedly vascular tumour lay fairly superficially in the ventral part of the lower pole of the right kidney The vessels were wide and tortuous and strikingly resembled those seen in vascular renal carcinomas The tumour derived it vascular supply from three sources viz an intrarenal branch of the right renal artery a capsular artery al o arising from the renal artery and a lumbar artery the arterial circulation through the tumour was rapid (Fig 2)

Needle biopsies both of the tumour and the liver were performed The cytologic examina



Fig. 3. a) Medium power photomicrograph of the renal tumour. Predominating angiomatous (middle and upper left areas) and leiomyomatous components with only a small area of fat tissue (lower right) and strands of collagenous connective tissue. b) Another area of the renal hamartoma showing some of the large vascular slits probably responsible for the hypervascularized appearances at aortography. The walls of the spaces are infiltrated with inflammatory cells, mainly lymphocytes and plasma cells. c) Necrotic (bottom) and hyalinized areas of the tumour with invasion of inflammatory cells, mainly granulocytes. d) From the lipoma of the liver. No connective tissue capsule peripherally against the normal liver parenchyma (top). Van Gieson ×124

tion of the specimens from the renal tumour revealed blood, inflammatory cells and a few somewhat atypical larger cells The liver biopsy revealed microscopically normal liver parenchyma

Operation One month after the start of the symptoms the patient was operated upon with the diagnosis of renal carcinoma The right kidney was found to contain a tumour measuring about 3 cm×5 cm×5 cm and protruding from the ventral part of the lower pole of the kidney It was well encapsulated and not adherent to adjacent soft tissues A round yellowish white mass with a diameter of about 2 cm lay in the right lobe of the liver and was removed by a large wedge resection The surgical diagnosis was renal carcinoma with metastases in the liver

Histologic investigation On gross examination after decapsulation of the kidney it was observed that the capsule could also easily be stripped off the tumour which protruded from the convex surface of the kidney for about half its diameter The consistency of the tumour was firm and the cut surface was fibromatous and white with some interspersed yellowish necrotic hemorrhages The tumour was well encapsulated against the adjacent parts of the cortex and medulla of the renal parenchyma It had no connections with the renal pelvis the ureter or the soft tissue of the hilum The large vessels were normal The cut surface of the liver nodule was fairly typical of a sharply demarcated hepatic lipoma

On microscopic examination the renal tumour bore the characteristic appearances of a hamartoma of the so-called angiomyolipoma type (Fig 3a) There was however such a marked predominance of the angiomatous and leiomyomatous components that it was considered most appropriate to call the hamartoma an angioleiomyoma or lipoangiomyoma The malformed vessels in many regions had large intercommunicating slit spaces lined by normal endothelium (Fig 3b) Inflammatory foci were abundant both in the grossly necrotic areas (Fig 3c) and around the vascular spaces (Fig 3b) The deep part of the tumour were surrounded by slightly compressed but otherwise normal renal parenchyma The lipoma of the liver was highly differentiated and not particularly rich in vessels it contained no other mesenchymal components and was not surrounded by any connective tissue capsule (Fig 3d) The final diagnosis was angioleiomyomatous hamartoma of the right kidney and lipoma of the liver

The post-operative course was uneventful and the patient left hospital 12 days after operation Clinical control four months later disclosed no noteworthy changes

Discussion

This case clearly illustrates the difficulties inherent in the preoperative diagnosis of so called angiomyolipomas of the kidney Neither the clinical and laboratory investigations, nor the cytologic examination of percutaneous biopsy specimens could definitely indicate the nature of the mass in the right kidney area Even the roentgenologic investigations, including aortography, failed to establish the correct diagnosis The combined results of the clinical, laboratory, cytologic and roentgenologic data, on the other hand suggested a renal carcinoma (hypernephroma), a diagnosis that received further support from the findings at operation of supposed metastases in the liver Although the erroneous preoperative and operative diagnosis in the present case did not result in incorrect therapy,

or at operation This has also been stressed by McQueeney Dahlen & Gebhart (1964) The histologic appearances of the liver lipoma in the present case constitute a reminder that multiple hamartomas may occur concomitantly in various organs a fact that may be of practical importance when dealing with cases of renal hamartomas (Klapproth et coll 1959 Essex 1966)

SUMMARY

The difficulties in the diagnosis of renal hamartomas are illustrated by a case in which the clinical laboratory cytologic roentgenologic and even the operative findings all produced the erroneous diagnosis of renal carcinoma (hypernephroma)

ZUSAMMENFASSUNG

Schwierigkeiten bei der Diagnose renaler Hamartomen werden mit einem Fall illustriert in dem die klinischen Zeichen die Laborergebnisse die Zytologie die Radiologie und sogar die Operationsbefunde zu einer falschen Diagnose von Nierenkarzinom (Hypernephrom) führten

RÉSUMÉ

Les difficultes du diagnostic des hamartomes renaux sont illustrees par un cas dans lequel les signes cliniques les resultats de laboratoire la cytologie la radiologie et meme les constatations operatoire conduisaient tous au diagnostic errone de cancer du rein (hypernephrome)

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calamities of this kind have been reported to occur (KAY et coll 1966) Scrutiny of the reasons for the misinterpretations in the present case, and some suggestions on the possibilities of diagnosing angiomyomatous hamartomas of the kidney may therefore be of some practical importance

The reason why fever and anemia with a high ESR and elevated serum iso enzyme activity were present in this case was obviously the occurrence of large necrotic and inflamed areas in the tumour (Fig 3, b and c) Such foci, with proliferating fibroblasts in the periphery, may also have produced the slightly atypical cells that were seen at percutaneous biopsy of the tumour It is difficult to establish a correct diagnosis by naked eye examination at operation without cutting into tumours the external appearances of non decapsulated angiomyolipomas and liver lipomas do not differ from those of renal carcinomas and liver metastases, respectively This is clearly illustrated by this case which was operated upon by a senior and experienced surgeon

As it has been claimed that in cases with a renal carcinoma (hypernephroma) located ventrally in the lower pole of the kidney the tumour may receive its blood supply from intrarenal and renal capsular arteries as well as from a lumbar artery (BOIJSEN & FOLIN 1961, FOLIN 1967), it was natural to classify the tumour in the present case as a renal carcinoma A scrutiny of the literature revealed however, that it has been noted previously that both angioleiomyomatous and angiomyolipomatous types of the renal hamartomas may be hypervascularized (KLAPPROTH et coll 1959 BLACKWELL, SAUNDERS & VAUGHAN 1964, LOWE & FRANK 1965 LANDGREN 1966, FOLIN 1967 PALMISANO 1967) According to these authors the vascularity of the hamartomas seems to be difficult to distinguish from that of renal carcinomas VIAMONTE et coll (1966) stated however, that a clear vascular differentiation was possible between a case of hamartoma associated with tuberous sclerosis and one of typical renal carcinoma The rich vascularization of the tumour in the present case is easily explained by the ample amounts of large vascular slits and smaller vessels of odd shapes (Fig 3, a and b)

It is almost impossible to arrive at a radiologic diagnosis of renal hamartoma by means of urography, pyelography and survey films The only exception may be when the lipomatous component predominates in the hamartoma so that areas with low absorption of radiation appear (KHILNANI & WOLF 1961, ADELMAN 1965) in survey and urographic roentgenograms The lipoma components in the present case were small

This case stresses the importance of considering the possibility of a renal hamartoma in the clinical and roentgenologic differential diagnosis of renal carcinoma It is also obvious from what has been said that a surgical biopsy specimen for cutting frozen sections, rather than a percutaneous needle biopsy for cytologic investigation, is needed for establishing the correct diagnosis before

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RENAL ARTERIOVENOUS MALFORMATION

by

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An arteriovenous shunt in a kidney may be a vascular malformation or may be acquired Arteriovenous renal aneurysms are rare but the condition is important to diagnose as the malformation may be of great consequence to the life and health of the patient

Case report

Female who at the age of 25 had intermittent pain in the right flank and gross haematuria during pregnancy At the time of delivery the systolic blood pressure was 125 mm Hg Left sided periodic headache had commenced post partum

At the age of 31 when she sought medical aid for her hemicrania, the blood pressure was 170/115 Angiography of the left cerebral hemisphere was normal and the condition was diagnosed as migraine A rise in her blood pressure to 190/130 caused her admission to hospital

There were no signs of cardiac decompensation auscultation of the heart was negative blood pressure recumbent was 170/100 standing 160/100 Routine blood counts and urine analyses were within normal limits creatinine concentration in serum 0 8 mg % creatinine clearance test [illegible]5 ml/min *Electrocardiography* routine chest roentgenography and the ophthalmology examination were all negative Urography revealed small rounded impressions in the necks of the right renal calyces but at repeat examination a few days later these changes were not so accentuated

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Fig 2 Angiography Arteriovenous malformation of the cirsoid type

venous shunts as congenital acquired or idiopathic They reserve the term congenital for those cases in which there are angiomatous or cirsoid appearances of the renal vessels with multiple arteriovenous communications The classification of McCook et coll into congenital and acquired arteriovenous communications the latter of which are grouped into (1) rupture of an arterial aneurysm into a vein (2) trauma cases (3) erosion cases and (4) iatrogenic cases seems highly satisfactory CRUMMY et coll divide arteriovenous malformations into two groups group I cirsoid characterized by multiple small tortuous channels and group II such in which the involved vessels are larger and the number of fistula connections limited Early filling of dilated veins from arteries that are no proportionately enlarged is characteristic

Fifteen cases of congenital intrarenal arteriovenous malformations that fit into the CRUMMY et coll group I (9 cases) and group II (6 cases) have been reported (see Table) It appears that women predominate (69 %) in both groups All patients excepting three in group I and two in group II have had gross haematuria (69 %) This is in accord with the opinions of NAFFAH et coll and LONG et coll who point out that haematuria is more characteristic of congenital shunts (these include arterial aneurysms that have ruptured into veins) than acquired shunts Heart decompensation is not a common finding The condition has been reported in four out of a total of 16 cases A bruit in the region of the malformation has been described in eight of 16 cases probably too low a figure as there



Fig 1 Pyelography Small rounded impressions in upper calyces of right kidney

Two years later the patient had attacks of pain in the right flank and passed blood stained urine containing coagula On admission to hospital the blood pressure was 170/90 the haemoglobin concentration 11 5 g % and the WBC count 12 000 the creatinine concentration in the serum was 1 2 mg %

Urography showed the kidneys to be in normal positions but there was no excretion from the right kidney the bladder was filled with coagula The patient continued to bleed and the haemoglobin concentration decreased to 8 1 g % Tomography of the right kidney revealed that it had been displaced laterally and cranially by a retroperitoneal haematoma Renal angiography disclosed that the cranial part of the right kidney contained irregular widened vessels that filled from distended arterial branches and emptied directly into tortuous wide veins an arteriovenous malformation

Right nephrectomy was performed Macroscopy revealed that there had been bleeding beneath the fibrous capsule and that the parenchyma was totally changed with alternating pale and haemorrhagic areas giving the impression of total infarction the renal pelvis was full of blood Microscopy indicated that there were numerous irregular blood filled vessels with predominating thin endothelium covering the walls between the thin walled vessels there were dilated arterial trunks with normal arterial walls Areas of infarction were present in the parenchyma

The patient made an uneventful recovery and was discharged two weeks after the operation at that time the haemoglobin concentration was 12 5 g % The systolic blood pressure was 115 at control four months later

Discussion

Some authors (CURRIE et coll , NAFFAH et coll , LONG et coll , THOMAS et coll , TWIGG et coll) count as congenital intrarenal malformation those fistulas that have occurred through rupture of an arterial aneurysm into a vein, while other authors (*BOIJSEN & KÖHLER MALDONADO, MCCOOK et coll*) consider these communications to be acquired MALDONADO et coll classify intrarenal arterio

graphy although FEINBERG & GOLDBERG stressed that cobblestone mucosal defects of the upper collecting system as seen at pyelography, is a striking and probably significant finding Some kind of calyceal distortion or filling defect has been evident in at least nine of the sixteen cases Angiography of the renal vessels has nevertheless been performed in all congenital cases except two none of which has been reported later than 1959 In one of these two cases operation was performed because urography suggested a renal tumor while in the other case a papilloma of the renal pelvis suggested at pyelography, proved at operation to be blood clots

SUMMARY

A case of renal arteriovenous malformation in a young woman acutely ill with haematuria and hypertonia is described The diagnosis was made by means of renal angiography The blood pressure returned to normal after nephrectomy The literature on the condition is reviewed

ZUSAMMENFASSUNG

Ein Fall von renaler arteriovenoser Missbildung *in einer akut kranken* jungen Frau mit Hamaturie und Hypertension wird beschrieben Die Diagnose wurde angiographisch gestellt Nach Nephrektomie ging der Blutdruck auf normal zuruck Die Literatur solcher Falle wird diskutiert

RÉSUMÉ

Présentation d un cas de malformation arterioveineuse rénale chez une jeune femme dont la maladie a commencé de façon aigue par une hématurie et une hypertension Le diagnostic a été fait par angiographie rénale La pression artérielle est revenue à la normale apres néphrectomie Revue de la littérature sur cette affection

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FEINBERG S B and GOLDBERG M F Arteriovenous communication of the kidney in a patient with hypertension Radiology 81 (1963) 601

Table

Cases (a total of 16) of renal arteriovenous malformation reported in the literature

Authors and year of publication	Age in years	Sex	Signs			
			Gross hematuria	Heart decompensation	Bruit	Diastolic hypertonia
Cirsoid type—10 cases						
SCHULZE BERGMANN 1954	59	Female	+	—	—	—
SLOMINSKI LAWS et coll 1956	19	Female	—	+	+	—
HUU HY & HUNG 1959	31	Male	+	—	+	—
BRINK 1960	29	Male	+	—	+	+
BOIJSEN & KOHLER 1962	29	Female	+	—	—	—
BOIJSEN & KOHLER 1962	30	Female	+	—	—	—
KARANI et coll 1962	27	Male	—	—	—	+
FEINBERG & GOLDBERG 1963	43	Female	+	+	+	+
CRUMMY et coll 1965	22	Female	—	—	+	+
GUNTERBERG	33	Female	+	—	—	+
Second type larger vessels—6 cases						
EDSMAN 1957	29	Female	+	—	—	—
HOFFMAN & FONTOURA 1958	68	Female	+	—	—	—
GRACE et coll 1960	53	Male	+	+	+	+
TWIGG et coll 1962	50	Female	—	+	+	—
LONG et coll 1964	24	Male	+	—	+	+
CRUMMY et coll 1965	39	Female	—	—	—	—

was sometimes no information given as to whether or not the lumbar region was subjected to auscultation In seven of the cases hypertonia was reported, one of these had ipsilateral stenosis of the renal artery as a possible cause (CRUMMY et coll) In this, as in three other cases (GRACE et coll, GUNTERBERG KARANI et coll) the diastolic blood pressure became normal (below 90) after nephrectomy One of the cases of hypertension was not operated on and in two cases the blood pressure remained elevated after operation MALDONADO stresses the existence of the syndrome (1) high output cardiac failure, (2) diastolic hypertension and (3) intraabdominal bruit in one third of the cases of fistula of the renal vessels It is obvious that this does not account for arteriovenous malformations, since only two of the sixteen cases displayed all these three signs

An intrarenal arteriovenous shunt can only be diagnosed by means of angio-

graphy although FEINBERG & GOLDBERG stressed that cobblestone mucosal defects of the upper collecting system as seen at pyelography, is a striking and probably significant finding Some kind of calyceal distortion or filling defect has been evident in at least nine of the sixteen cases Angiography of the renal vessels has nevertheless been performed in all congenital cases except two none of which has been reported later than 1959 In one of these two cases operation was performed because urography suggested a renal tumor while in the other case a papilloma of the renal pelvis suggested at pyelography proved at operation to be blood clots

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RÉSUMÉ

Presentation d un cas de malformation artérioveineuse renale chez une jeune femme dont la maladie a commence de façon aigue par une hematurie et une hypertension. Le diagnostic a ete fait par angiographie renale La pression arterielle est revenue a la normale apres nephrectomie Revue de la litterature sur cette affection

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OCCURRENCE OF VALVES IN THE MAIN TRUNK OF THE RENAL VEIN

by

N E AHLBERG O BARTLEY AND N CHIDEKEL

The increasing use of elective angiography in modern roentgenologic diagnostics has indicated the need for more detailed anatomical information Both the renal and gonadal veins have in recent years been subjected to investigation from the roentgenologic as well as from the clinical and physiologic points of view (HELANDER et coll 1958 EDWALL 1958 HELANDER & LINDBOM 1960 FUCHS 1961 AHLBERG et coll 1965 1966)

Information on the valves varies in the literature A number of authors describe the presence of valves in the renal veins (HENLE 1868 RIVINGTON 1873 GEGENBAUER 1903 FAGARASANU 1938 and KUGELGEN & GREINEMANN 1957), while others deny their existence (LUSCHKA 1863 GLANTENAY & GOSSET 1904 MOLLENDORFF 1943 DALLA PALMA & SERVELLO 1956 GILLOT et coll 1960 and BARRY et coll 1962) The majority of the authors who have observed valves in the renal veins have given no frequency figures the exceptions being RIVINGTON and FAGARASANU who investigated *ten* and thirty autopsy cases respectively The former found valves on the right side in three and on the left side in two cases while the latter observed valves on the right side in twenty one cases and on the left in eleven cases

It has been stated that the left gonadal vein with few exceptions empties into

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Table 1

Frequency of valves in the main trunk of the renal vein

Sex	Renal vein	Number of specimens		
		Total	With valves	Per cent
♂	Left	28	1	4
	Right	27	6	22
♀	Left	50	2	4
	Right	38	12	32
Total	Left	78	3	4
	Right	65	18	28

the renal vein (ANSON & DASELER 1961) while the right gonadal vein in 90 % of cases opens into the inferior vena cava caudal to the termination of the renal vein (SAURAMO 1947).

The present authors have investigated the occurrence of valves in the cranial portions of the left and right gonadal veins (AHLBERG et coll. 1965, 1966). These studies were carried out on autopsy material consisting of specimens, in 186 cases from the left and in 84 cases from the right side. It could be established that valves occur more often in the right than in the left gonadal vein and more often in women than in men. To our knowledge, no investigation has earlier been performed on the possible interrelation between the presence of valves in the renal and gonadal veins and the drainage site of the latter.

Autopsy specimens from adults were examined. The presence of valves in the renal and gonadal veins was studied on the left side in 78 specimens (from 28 males and 50 females) and on the right side in 65 specimens (from 27 males and 38 females). The drainage site of the left gonadal vein was noted in 190 specimens and of the right gonadal vein in 65 specimens.

Results

Presence of valves in the main trunk of the renal vein. As may be seen from Table 1, a pair of valves were present in the left renal vein in 4 % of the specimens while the corresponding figure for the right renal vein was 28 %. The incidence of valves was significantly higher in the right renal vein than in the left renal vein. No difference in relation to sex was noted. On the left side the pair of valves were situated about 1.5 cm from the inferior vena cava medial to the drainage site of the gonadal vein and on the right side at the termination of the renal vein in the inferior vena cava.

Presence of valves in the gonadal vein Valves were absent on the left side in eleven of the 28 male specimens and in seven of the 50 female specimen i e in 39 % and 14 % respectively These figures differ significantly and confirm our earlier finding that men more often than women lack valves in the left gonadal vein On the right side six of 27 male specimens (22 %) and three of 28 female specimens (8 %) lacked valves This difference is not statistically significant In a larger material (AHLBERG et coll 1966) however the authors noted that valves in the right gonadal vein were missing more often in men than in women

Drainage sites of the gonadal veins The left gonadal vein emptied into the renal vein in all but one case The exception occurred in a female specimen which had a duplication of the inferior vena cava The left gonadal vein terminated in the left vena cava which in turn emptied into the left renal vein

The right gonadal vein emptied into the inferior vena cava immediately caudal to the right renal vein in fifty seven of the 65 specimens In the majority of these 57 cases very small anastomoses between the right gonadal and renal veins were observed The gonadal vein terminated in the right renal vein in seven of the specimens (4 male and 3 female) In the remaining case (*female*) the right gonadal vein divided into two branches of equal width 3 cm caudal to the renal vein one of these emptied into the inferior vena cava and the other into the right renal vein Thus in 88 % of cases the right gonadal vein emptied into the inferior vena cava

Relation between presence of valves in the renal and gonadal veins and the drainage site of the gonadal vein (Table 2) Two cases have been excluded one with a double inferior vena cava and another one in which the right gonadal vein drained into the right renal vein as well as into the inferior vena cava Valves were lacking in the left gonadal vein in seventeen of the specimens two of these (12 %) had valves in the left renal vein. Only one out of 60 specimens with valves in the left gonadal vein (2 %) had valves also in the left renal vein

The right gonadal vein drained into the right renal vein in seven specimens of these five had no valves in the gonadal vein four of which (80 %) had valves in the renal vein The two specimens with valves in the gonadal vein had no valves in the renal vein however

There was thus a tendency on the left side towards a higher frequency of valves in the renal vein when these were absent in the gonadal vein There was a similar tendency on the right side when the gonadal vein emptied into the renal vein but not when it drained into the inferior vena cava

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Drainage sites of the gonadal veins The left gonadal vein emptied into the renal vein in all but one case The exception occurred in a female specimen which had a duplication of the inferior vena cava The left gonadal vein terminated in the left vena cava which in turn emptied into the left renal vein

The right gonadal vein emptied into the inferior vena cava immediately caudal to the right renal vein in fifty seven of the 65 specimens In the majority of these 57 cases very small anastomoses between the right gonadal and renal veins were observed The gonadal vein terminated in the right renal vein in seven of the specimens (4 male and 3 female) In the remaining case (female) the right gonadal vein divided into two branches of equal width 3 cm caudal to the renal vein one of these emptied into the inferior vena cava and the other into the right renal vein Thus in 88 % of cases the right gonadal vein emptied into the inferior vena cava

Relation between presence of valves in the renal and gonadal veins and the drainage site of the gonadal vein (Table 2) Two cases have been excluded one with a double inferior vena cava and another one in which the right gonadal vein drained into the right renal vein as well as into the inferior vena cava Valves were lacking in the left gonadal vein in seventeen of the specimens, two of these (12 %) had valves in the left renal vein Only one out of 60 pecimens with valves in the left gonadal vein (2 %) had valves also in the left renal vein

The right gonadal vein drained into the right renal vein in seven specimens of these five had no valves in the gonadal vein four of which (80 %) had valves in the renal vein The two specimens with valves in the gonadal vein had no valves in the renal vein however

There was thus a tendency on the left side towards a higher frequency of valves in the renal vein when these were absent in the gonadal vein There was a similar tendency on the right side when the gonadal vein emptied into the renal vein but not when it drained into the inferior vena cava

Table 1

Frequency of valves in the main trunk of the renal vein

Sex	Renal vein	Number of specimens		
		Total	With valves	Per cent
♂	Left	28	1	4
	Right	27	6	22
♀	Left	50	2	4
	Right	38	12	32
Total	Left	78	3	4
	Right	65	18	28

the renal vein (ANSON & DASELER 1961) while the right gonadal vein in 90 % of cases opens into the inferior vena cava caudal to the termination of the renal vein (SAURAMO 1947).

The present authors have investigated the occurrence of valves in the cranial portions of the left and right gonadal veins (AHLBERG et coll. 1965, 1966). These studies were carried out on autopsy material consisting of specimens, in 186 cases from the left and in 84 cases from the right side. It could be established that valves occur more often in the right than in the left gonadal vein and more often in women than in men. To our knowledge, no investigation has earlier been performed on the possible interrelation between the presence of valves in the renal and gonadal veins and the drainage site of the latter.

Autopsy specimens from adults were examined. The presence of valves in the renal and gonadal veins was studied on the left side in 78 specimens (from 28 males and 50 females) and on the right side in 65 specimens (from 27 males and 38 females). The drainage site of the left gonadal vein was noted in 190 specimens and of the right gonadal vein in 65 specimens.

Results

Presence of valves in the main trunk of the renal vein. As may be seen from Table 1 a pair of valves were present in the left renal vein in 4 % of the specimens while the corresponding figure for the right renal vein was 28 %. The incidence of valves was significantly higher in the right renal vein than in the left renal vein. No difference in relation to sex was noted. On the left side the pair of valves were situated about 1.5 cm from the inferior vena cava medial to the drainage site of the gonadal vein and on the right side at the termination of the renal vein in the inferior vena cava.

for the occasional failure to perform selective catheterization may perhaps be that valves are present in these veins. The present results concerning the drainage site of the gonadal veins are in accord with those in the literature. On the left side the gonadal vein almost always emptied into the renal vein, while on the right side about 90 % emptied into the inferior vena cava and only 10 % into the renal vein. The majority of the cases in which the right gonadal vein emptied into the inferior vena cava had small anastomoses between the renal and gonadal veins. These have already been demonstrated in an angiographic investigation of an autopsy material (AHLBERG et coll. 1967). The present study of valve incidence in the renal and gonadal veins and the drainage site of the gonadal veins reveals intimate interrelations. The frequency of valves in the renal veins is higher when valveless gonadal veins open into them than when they are supplied by gonadal veins with valves.

According to KUGELGEN & GREINEMANN valves occur more often in the foetus and in children than in adults. The anatomical differences between right and left gonadal and renal veins may be connected with the complicated embryologic development. At the 15 mm embryonic stage there are according to MCCLURE & BUTLER (1925) and REIS & ESENTHER (1959) three longitudinally coursing venous channels on both sides, namely the subcardinal, supracardinal and dorsal cardinal veins. The two first named vessels on the right side take part in the formation of the inferior vena cava and are joined by an anastomosis at the level of the embryonic renal veins. At the same level the intersubcardinal anastomosis joins the right and left subcardinal and supracardinal veins. The right portion of the intersubcardinal anastomosis is included in the formation of the inferior vena cava. At the 22 mm embryonic stage there are double renal veins *bilaterally*, the dorsal veins usually cease to develop. The right ventral vein forms the right renal vein and empties into the inferior vena cava, while the left renal vein consists of a lateral part comprising the remaining embryonic renal vein and a medial part representing the left portion of the intersubcardinal anastomosis. The anatomical differences between the right and left renal veins may thus be explained. The gonadal veins become demonstrable at the 22 mm embryonic stage. Bilaterally the caudal portion is formed by a *vein leading* from the gonad to the mesonephros and the cranial portion of the subcardinal vein which empties into the left or right part of the intersubcardinal anastomosis. As was mentioned before the left of these vessels is involved in the formation of the left renal vein while the right becomes a part of the inferior vena cava. This embryologic development is responsible for the different drainage sites of the two gonadal veins.

There are many anastomoses between the dorsal cardinal vein and the subcardinal vein. On the right side one of these may remain and in combination with the cranial part of the dorsal cardinal vein form the *cranial* portion of the right

Table 2

Frequency of valves in the main trunk of the renal vein correlated to valve status and drainage site of the gonadal vein

Gonadal veins		Number of specimens		
Drainage	Valves	Total	With valves in the renal veins	Per cent
Left renal vein	Absent	17	2	12
	Present	60	1	2
Right renal vein	Absent	5	4	80
	Present	2	0	0
Right vena cava	Absent	3	0	0
	Present	54	13	23

As may also be seen from Table 2, valves occurred more often in the right renal vein when the right gonadal vein drained into it than when the gonadal vein terminated in the inferior vena cava. This mainly depended on the male specimens in which a significant difference compared to the female material was noted.

Valves were present in the right gonadal vein in fifty four of 57 specimens (95 %) when this vein drained into the inferior vena cava. On the other hand when it emptied into the renal vein the corresponding figures were two out of seven specimens (29 %). Valves in the right gonadal vein thus occurred at a significantly higher frequency when it emptied into the inferior vena cava than when it terminated in the renal vein.

It may be stated in brief that there is a tendency towards a higher incidence of valves in renal veins that are supplied by gonadal veins without valves than by those with valves. On the right side valves occur significantly more often in gonadal veins that terminate in the inferior vena cava than in those that empty into the renal vein.

Discussion and Conclusions

Selective catheterization of the renal veins is usually technically easy to perform but in exceptional cases the catheter cannot be passed into the renal vein. There are conflicting reports in the literature on the presence of valves in the renal veins. According to the present findings, however, valves are found on both sides although significantly more often on the right than on the left side. The reason

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gonadal vein If the embryologic development follows this line, the right gonadal vein would empty into the renal vein since the dorsal cardinal vein has a connection with the embryonic renal vein In a similar manner, the anastomoses often occurring between the right renal and gonadal veins may be explained when the latter empties into the inferior vena cava

SUMMARY

The incidence of valves in the renal and gonadal veins and the drainage sites of the latter were investigated in an autopsy material Valves occur in the renal vein on both sides but more often on the right than on the left side and even more frequently when valveless gonadal veins empty into the renal vein

ZUSAMMENFASSUNG

Das Vorkommen von Klappen in den Nierenvenen und in den Ovarial oder Hodenvenen wurde auf dem Sektionstisch studiert Klappen konnen in beiden Nierenvenen auftreten haufiger aber auf der rechten als auf der linken Seite und noch haufiger wenn klappenlose Gonadenvenen in die Nierenvenen ausmunden

RÉSUMÉ

Les auteurs ont recherche au cours d autopsies la frequence des valvules sur les veines *renales et gonadiques* et le lieu de drainage de ces dernieres Il peut exister des valvules sur la veine renale des deux cotes mais plus souvent à droite qu à gauche et encore plus souvent quand des veines gonadiques sans valvules se drainent dans la veine *renale*

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Fig 1 a) Normal lymphogram in vi o showing the interstitial space subep c d al collectors mediastin l nodes ar d th as cend ng lymph vessels as far as to the venous junct on b) Roentger ogram of specimen on industrial f lm interst tial space myocard al subep card al and deep perivenous collectors with efferent trunk

evolution of necrosis and fibrosis are influenced by the permeability or imper meability of the lymphatic channels

Knowledge of the morphology and function of the cardiac lymphatic system has up to now been based upon anatomical studies in which stains or hydrogen peroxide (14) have been used The cardiac lymph has also been investigated under normal and pathologic conditions (9) We have devised and used a roentgenologic technique by which the identification of the normal anatomy (Fig 1) of the interstitial space and the lymphatic system of the heart has been achieved (2 3) A study of the changes during experimental myocardial infarction has been undertaken and forms the subject of the present communica tion The method seems to be more useful than staining since it demonstrates the lymphatic system in its entirety i e the superficial as well as the deep collectors The interruption of the lymphatic collectors in surgery, cardiac arrest with myocardial hypoxia and the possibility of heart transplants in the near future with accompanying total suppression of lymphatic drainage, con stitute problems to be considered from the angle of experimental approach SYMBAS et coll (1966) using staining methods have studied the changes in the lymphatic system following ligature or experimental section of the collectors that run alongside the coronary blood vessels and have shown that a restitution

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LYMPHATIC CIRCULATION IN EXPERIMENTAL MYOCARDIAL INFARCTION

by

A CELIS, H MARQUEZ, H DEL CASTILLO and D MIJANGOS

The changes produced in experimental myocardial infarction have been thoroughly studied for gross and microscopic pathologic features Special attention has been paid to the ultrastructure (1), the reversibility or irreversibility of the myocardial damage (26, 13), and changes in electric polarity The metabolic, biochemical, enzymatic and electrolytic changes, both local and general, that arise as a result of myocardial hypoxia and of the transition from an aerobic to an insufficient anaerobic metabolism have all been discussed in the literature (5, 7, 8, 12, 15, 16, 18, 21, 22, 25, 26) Changes occurring in the contractile elements during myocardial infarction are well known but no studies seem to have been made of alterations taking place in the interstitial space where the interchange of elements indispensable for the myocardial fibre metabolism takes place The lymphatic system in the area of anoxia has apparently not been investigated A review of the literature on the subject disclosed only one paper, one by KLINE et coll (1964) who described the histologic difference in experimental myocardial infarction with or without obstruction of the cardiac lymph flow They concluded that the size, depth and

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Fig 1 a) Normal lymphogram in vivo showing the interstitial space subepicardial collectors mediastinal nodes and the ascending lymph vessels as far as to the venous junction b) Roentgenogram of specimen on industrial film interstitial space myocardial subepicardial and deep perivenous collectors with efferent trunk

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Knowledge of the morphology and function of the cardiac lymphatic system has up to now been based upon anatomical studies in which stains or hydrogen peroxide (14) have been used The cardiac lymph has also been investigated under normal and pathologic conditions (9) We have devised and used a roentgenologic technique by which the identification of the normal anatomy (Fig 1) of the interstitial space and the lymphatic system of the heart has been achieved (2 3) A study of the changes during experimental myocardial infarction has been undertaken and forms the subject of the present communication The method seems to be more useful than staining since it demonstrates the lymphatic system in its entirety i e the superficial as well as the deep collectors The interruption of the lymphatic collectors in surgery cardiac arrest with myocardial hypoxia and the possibility of heart transplants in the near future with accompanying total suppression of lymphatic drainage constitute problems to be considered from the angle of experimental approach SYMBAS et coll (1966) using staining methods have studied the changes in the lymphatic system following ligature or experimental section of the collectors that run alongside the coronary blood vessels and have shown that a restitution

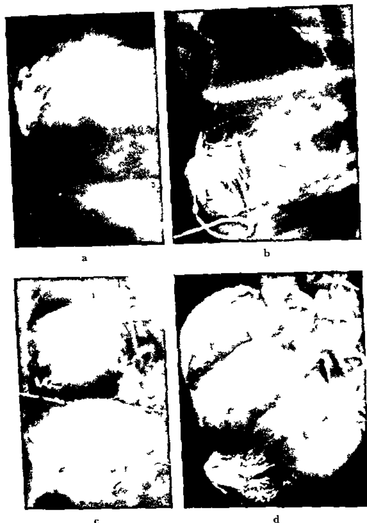


Fig 2 Immediate lymphogram of area of infarction after coronary ligation showing interstitial space normal subepicardial and mediastinal collectors

of the drainage towards the mediastinal trunks occurs after the second operative week

Material and Methods Experimental infarction has been produced by ligation of the anterior descending branch of the coronary artery at different levels in the first few cases single complete ligature was done Several animals were lost because of ventricular fibrillation, later HARRIS technique (1950) was followed with better results, i e occlusion and ligation of the coronary vessel was preceded by staining of the subepicardiac lymphatic trunks so as to avoid trauma as much as possible, or their occlusion within the ligature Infarction was demonstrated by EKG as well as by pathologic examination

Thirty three animals survived arterial ligation Lymphography was performed in twenty immediately after arterial occlusion by injecting the contrast medium into the area of ischemia as well as into the non ischemic area In another group the same was done after 24, 48 and 72 hours, and 9, 10, 11 85 and 130 days after ligation, while in a few animals lymphography was repeated as many as three times during the clinical evolution of the infarction Staining and lymphography were performed in three cases, while the coronary artery was ligated, in order to ascertain changes induced by dissection and ligation in the absorption and drainage of the medium Lastly, in two animals the ligature



F g 3 Exp rimental nf ct on a) Imm diate lymphogram b) Lympho gram after 85 d ys Re canali ation of the *subepicard* al collectors (ab ent n the first lymphogram) c) Lymphogram after 130 days Scanty d a nage in i o f om the nf ted a ea to m diast num I) Spec men how homogene ty of nt stitial sp ce and *m nim* l lymphatic drain ge fib osis of the area of nf rct on

was placed in situ but not tied so that the changes induced in the lympho gram merely by the trauma of surgery could be ascertained

A roentgenogram was taken immediately in every animal and in some a few days later as well Cinelymphography was carried out in two cases and



a

Fig 4 a) Immediate lymphogram of area of infarction showing lymph derivation and filling of colllectors and mediastinal lymph nodes b) Roentgenogram of specimen shows the interstitial space lymph derivation and perivenous lymph vessels



b

Lastly, in a few cases, after completion *in vivo* of the roentgenographic study, the animals were sacrificed and films obtained Fine grain industrial film (Kodak type M) was used, which gives optimum detail of the interstitial space structures and of the lymphatic collectors of the heart

Results

Serial lymphography and cinelymphography demonstrated that in experimental myocardial infarction the filling time and the morphologic features of the collectors and mediastinal nodes remained unaltered In every case, a drainage pathway remained from the anoxic interstitial space to the systemic veins, and films obtained during the following days indicated absorption of the contrast medium and its persistence in the mediastinal lymph nodes (Fig 2)

The films obtained in vivo and the films of the heart after its removal revealed that in the animals subjected to experimental infarction the visible interstitial space was normal as compared with the control animals, during the first few hours and the following days as well as in the chronic stage The interstitial space function, as indicated by absorption and drainage of the injected medium, persisted with the ischemic area When the infarction had developed into substitution fibrosis, lymphography showed disappearance of the interstitial space and non drainage of the medium (Fig 3, b and c)

Drainage of the interstitial space sometimes took place through the subepicar



Fig 5 Immediate lymphogram of ischemic area showing lymph derivation and late contrast filling of the mediastinal collectors

diac collectors but generally followed deep derivations which do not appear in normal lymphograms (Figs 4 5 and 6) The change must lie at the communication of the lymphatics of the ischemic area with the subepicardiac collectors since when the injection is performed in the same animal in a non ischemic area the normal collectors are filled When lymphography immediately followed ligation there was no drainage from the ischemic interstitial space through the subepicardial channels although further lymphograms revealed re communication between both systems

Injection of contrast medium before and after induced ischemia proved that normal drainage persists and is enhanced in the latter case and that new pathways appear This is evidence of the integrity of the subepicardiac collector following arterial dissection and ligation and that the ischemic area apparently connects with systems of lymphatic derivations or shunts

Lymphograms obtained in a few cases immediately after infarction disclosed irregularly scattered smudges in the myocardium These were ascribed to a faulty technique namely tearing of the subepicardial collectors during dissection (27)

Discussion

Lymphography in myocardial infarction has demonstrated in the main that drainage of the interstitial space from the ischemic area takes place by



Fig 6 a) Lymphogram of infarction area after 24 hours No drainage to the *subepicardial lymph vessels the perivenous lymphatics begin to appear and the* mediastinal trunks are filled b) Specimen showing the interstitial space and the lateral collectors *beginning to appear probable filling of the upper trunks*

normal subepicardial collectors, derivations or shunts, or re communications, and that a lapse of undetermined duration of functional and anatomical integrity of the cardiac lymphatic system occurs

The ischemic area in a dog with recent infarction usually drains through derivations while the non ischemic area is drained through the normal subepicardial channels It may thus be stated that the obstruction lies at the junction of the ischemic area and subepicardial lymphatics so that the lymph follows new routes via lymph vessels that do not function under normal conditions On the other hand, the apparent absence of permeability of these lymphatics could be attributed to surgical trauma, or to their having been included in the arterial ligation, but we do not believe in this since previous staining identified the lymphatics, no smudges of medium typical of lymph vessel rupture appeared in the films (27), and no lymphatic stasis (Fig 7) was evident In addition, the injection of contrast medium into a normal area rendered the lymphatics visible Our suggestion would certainly have been strengthened if the arterial occlusion had been produced by intracoronary thrombus (6) through an electric discharge (23), or with an intra arterial magnesium aluminium alloy (10, 19) Cannulation of the left coronary artery was performed through the carotid artery in two animals, both of these died however from ventricular fibrillation



Fig 7 Ligation of coronary and lymphatic trunks immed ate lymphogram of area of infarc tion norm l interstitial space and good lymphatic drainage d latation of trunks due to stas s

Lymphography and cinelymphography demonstrate morphologically the interstitial spaces as well as the absorption of the medium at this level and its flow via myocardial and subepicardial lymphatics — and their derivations the cardiac node and the mediastinal collectors — to their junctions with veins If it is accepted that lymphography provides a true static and *dynamic* representation of conditions it is evident that the lymphatic system undergoes *no* change during experimental myocardial infarction Furthermore this anatomical and functional integrity persists for an unknown period but dis appears when substitution fibrosis becomes established The flow of lymph con tinues however either through the normal pathways or through *permeation* of the deep perivenous derivations

The lymphatic system is in effect an homeostatic mechanism to prevent excessive changes in the interstitial fluids indispensable for cellular *metabolism* It is also maintains constant plasmatic levels by allowing the return to the blood stream of fluids macromolecules proteins long *chain* fatty acids and enzymes coming from the capillary blood vessels as well as those produced by the cells themselves (21)

Freservation of the system and its capacity of absorption implies that in myo cardial infarction elimination of cellular *components* due *to* congestion ede matous fluid and proteins due to necrosis enzymes and in situ liberated electro lytes can still take place The drainage of these elements may well account for

their increase in the blood serum, a finding of some diagnostic value in this condition This appears to support the findings of SYMBAS et coll (1966) that the lymphatic system is important in the removal (clearance) of blood injected into the myocardium as well as of its by products due to necrosis as also in the supply of the elements used in tissue repair and healing

Several problems to be investigated regarding the lymphatic circulation in myocardial infarction remain Those that have been mentioned include the assessment of electrolytes, proteins and enzymes in the lymph coming from the anoxic area, the appreciation of the evolution of the venous system and its relations with the lymphatic system and the evolution of the latter when the efferent trunk is ligated in experimental infarction

Conclusions

The interstitial space in the area of infarction remains morphologically normal throughout the course of the infarction up to the onset of fibrosis The interstitial space during experimental myocardial infarction retains its power of absorption of the contrast medium, and its connections with the lymphatics of the mediastinum and the systemic veins persist through the normal collectors, and more frequently through derivations not apparent in normal lymphography The conservation during a certain period of the anatomical and functional integrity of the lymphatic system ensures drainage of edematous fluid, elements due to congestion, macromolecules, such as proteins resulting from necrosis, and the in situ liberated enzymes from the infarcted area to the systemic veins It is probable that the lymphatic system plays an important role in the repair of the damaged anoxic area

SUMMARY

Lymphography and cinelymphography by a special roentgen technique were employed to demonstrate the condition of the heart in 33 dogs subjected to cardiac infarction Special attention was paid to changes in the interstitial space in the region of the infarction area

ZUSAMMENFASSUNG

Nachdem kunstliche Infarkte bei 33 Hunden hervorgerufen wurden wurde der Zustand des Herzens mittels einer speziellen Rontgenmethode mit Hilfe von Lymphographie und Cinelymphographie studiert Besondere Beachtung wurde dem interstitiellen Raum in der Gegend des Infarktes gewidmet

RÉSUMÉ

Les auteurs ont employé la lymphographie et la cinélymphographie au moyen d une technique radiologique speciale pour étudier l état du cœur sur 33 chiens soumis à un infarctus cardiaque Ils ont examiné spécialement les modifications de l espace interstitiel dans la région de l infarctus

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FROM THE ROENTGENDIAGNOSTIC DEPARTMENT KAROLINSKA SJUKHUSET
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PATHOLOGIC FEATURES OF BONE

Tentative classification of bone lesions

by

NILS P G EDLING

Difficulties in classification are inevitably encountered when studying bone lesions Many classification systems have been suggested A real cause of confusion is the multitude of names given to the same lesion often attached to the names of writers The critical student may say that every new contribution to the classification will increase the confusion but as long as the middle exists there will be unceasing attempts to arrive at a satisfactory solution

It seems essential that a classification should be based on the fact that bone is a specialized connective tissue with osteogenic capacity It is moreover just as necessary to define any tissue that is concerned in the growth or repair of bone as osteogenic (Dorland) whether fibrous cartilaginous or osseous Bone has certain typical features the different stages of its formation from mesenchyma to maturity the growth and modelling of the skeleton in children and adolescents and the rebuilding of mature bone tissue throughout life Disturbances in any of these processes will result in abnormal osseous structures that may be substituted by non-osteogenic tissues Pathologic conditions of bone are often a question of too much or too little osseous tissue (FOLLIS 1957)

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hondromatous tissue The benign chondromatous changes referred to as non alcified and calcified en and ecchondromas as well as chondromyxomas may e called dyschondroplasias They may also be caused by trauma Malignant hondromatous changes represent the chondrosarcomatous entity of the osteogenic arcomas when osteogenic is used in its proper sense Chondrosarcomas occur late in life chiefly in pelvic and trochanteric areas that have undergone vigorous bone formation during growth

False osseous tissue may also be laid down in bone formation solitary exostoses and osteomas are included in this group They should be termed dysosteoplasias and may also be post traumatic Multiple chondromatoses and multiple osteochondromas are usually combined with marked deformity of the metaphyseal regions and inhibition of bone growth they are included below in disorders in modelling

Circumscribed or disseminated changes with excessive bone formation are termed melorheostosis and osteopoikilosis condensans localisata and disseminata The distribution of melorheostosis may indicate that there has been considerable bone formation for long periods of growth in extended areas of one or two extremities or parts of these Osteopoikilosis is mainly distributed in the epiphyses and other bones with appositional bone formation The rare streaky type of osteopoikilosis has a metaphyseal and ilial distribution This approaches osteopetrosis in growing bone a more general formation of excess bone probably caused by a reduced osteoclastic capacity All these changes that represent too much bone formation may be called hyperdysosteoplasias and may be s parated into solitary circumscribed disseminated and generalized hyperdysosteoplasia

General changes with diminished bone formation occur in rickets osteomalacia hypophosphatasia and osteogenesis imperfecta The pathogenesis of infantile rickets and of osteomalacia in the adult is unique their separation into two entities is unnecessary as the apparent difference is due to age only and is not qualitative The markedly more local distribution of the changes in children is due to the intense metabolism occurring in *the metaphyses* of growing long bones Hypophosphatasia is similar to rickets as regards defective mineralisation of the osteoid tissue This disturbance is however, not caused by avitaminosis but may be the result of deficiency of alkaline phosphatase Osteogenesis imperfecta is considered a mesenchymal hypoplasia with osteoblastic insufficiency These lesions represent generalized hypodysosteoplasias

Osteitis deformans (Paget s disease) starts with a replacement of the original mature bone by connective tissue and then by irregularly arranged cancellous tructures around the remnants of ordinary bone structures An adequate and informative name is deforming dysosteoplasia

Disturbances of modelling of bone in the growing individual may lead to

The *formation of bone* may be disturbed or impaired at any stage. This means that not only abnormal osseous tissue but fibrous and cartilaginous tissues may also constitute a bone lesion (EDLING 1964). When these tissues occur simultaneously, quantitative differences between them do not primarily indicate different pathologic entities.

Benign fibrous changes are conventionally divided into fibrous cortical defects, non-ossifying fibromas, bone cysts, aneurysmal bone cysts, fibrous dysplasia, osteitis fibrosa, subperiosteal giant cell tumours, giant cell tumours, osteoclastomas, and so on. Most of these changes are caused by bone formation disturbances in the *epiphyseal plate, and their final site in the growing long bone consequently* depends on age. The macroscopic and microscopic appearances of such changes are influenced by the vascularity of the affected area (EDLING 1965). Cystic *changes in a compact diaphysis, for example, tend to result in fluid degeneration* of the contents, while spongious epiphyseal changes, in which extensive destruction of bone tissue and hemorrhage may occur, include a profusion of osteoclastic giant cells. It seems both adequate and informative therefore to call these changes epiphyseal, metaphyseal, diaphyseal, and subperiosteal dysfibroplasia when situated in long bones. Bone in cartilage growing by apposition may also be subject to dysfibroplasia in the form of faulty growth (cysts and aneurysmal bone cysts, for example). In addition circumscribed dysfibroplasias may be found in mature bone as a result of trauma or hyperparathyroidism. Post-traumatic dysfibroplasia is usually subperiosteal while in hyperparathyroid dysfibroplasia *the appearance corresponds to the site, as in the* solitary lesion. Hyperparathyroid dysfibroplasia also occurs in membranous bone. There is every indication that the fibrous component of dysfibroplasia arising from faulty development is as well differentiated as that of dysfibroplasia resulting from hyperparathyroidism, despite differences in etiology and pathogenesis. The general dysfibroplasia of hyperparathyroidism is dealt with below.

Malignant fibrous changes of bone are usually divided into fibrosarcomas and osteogenic sarcomas with sub-entities. Most of these changes are confined to areas of the long bones where growth is most intense before or just after the *fusion of the physes (EDLING 1964, 1965). All pathologists agree that the ground* substance in both varieties of tumour is fibrosarcomatous (JAFFE 1958, BOYD 1961, ACKERMAN & DEL REGATO 1962, LICHTENSTEIN 1965) with varying occurrence of neoplastic, cartilaginous or osseous elements. It therefore seems most reasonable to consider them as one kind of fibrosarcoma with varying degrees of abortive osteogenic capacity. When osteogenic is used in its true sense this tumour would represent the fibrosarcomatous entity of the osteogenic sarcomas.

A disturbance of bone formation may result not only in the *laying down of* fibrous tissue in place of normal bone but also in the production of false

Table 1 *(cont)*

Dysostosis	Dystrophy
Diastrophic dwarfism	Hypothyroidism
Chondroectodermal dysplasia	Hypo- and hyperpituitarism
Dyschondrosteose	Hurler s syndrome
	Rachitiform disease
	Gaucher s disease
	Heavy metal intoxication
	Hyperparathyroidism
Cleidocranial dysostosis	Hormonal osteoporosis
	Vitamin A and D intoxication

supply and the ordinary process of continuous rebuilding has been interrupted in the second disorder This is why *necrotic bone has* been wrongly termed osteosclerotic In point of fact necrotic bone retains its density while the surrounding intact bone loses its density due to disuse and *vascular reaction*

A disturbance of the rebuilding of mature bone is usually caused by hormonal under or overaction or by non osteogenic cellular activity The *recognition that* despite foreign stimulation the structural change is still caused by an osteogenic process is important This latter is not a direct influence from hormones or foreign cells upon the bone cells and matrix but a stimulation to abnormal activity of osteoblasts and osteoclasts resulting in abnormal deposition or abnormal resorption of bone This explains the anatomical and roentgenologic similarity that may occur with different bone lesions On the other hand the difference in vascularization between spongious and compact bone explains the fact that depending on site one pathologic entity may produce different macroscopic and microscopic *appearances When normal* bone tissue is broken down by foreign cell invasion the substituting non osteogenic tissues naturally provide a major contribution to the histologic features The *degree of differentiation* indicates the prognosis

The most common disorder of mature bone has a *hormonal* basis i e osteoporosis due to gonadal deficiency (ageing) Disuse and hypercorticoidism may also cause osteoporosis A common feature in these conditions is inhibition of

Table 1

Broad classification and terminology of dysplasia (according to RUBIN*)*

	Hypoplasia variety congenita and tarda	*Hyperplasia*
Epiphysis	Spondyloepiphyseal dysplasia *Multiple epiphyseal dysplasia*	Dysplasia epiphysalis hemimelica
Physis	*Achondroplasia* Metaphyseal dysostosis	*Hyperchondroplasia* Enchondromatosis
Metaphysis	Hypophosphatasia Osteopetrosis Craniometaphyseal dysplasia	Multiple exostoses
Diaphysis	Osteogenesis imperfecta Idiopathic osteoporosis	Progressive diaphyseal dysplasia Hyperphosphatasemia

deformities that include joints. They are a motley company that may be grouped as congenital hypo- and hyperdysplasias and malformations. RUBIN (1964) classified them as epiphyseal, physeal, metaphyseal and diaphyseal dysplasias of long and short tubular bones, with the inclusion of modelling errors of skull, vertebrae and pelvis.

RUBIN's Broad classification and terminology of dysplasia is reproduced in Table 1. The structural changes predominate over the modelling errors in osteopetrosis, hypophosphatasia and osteogenesis imperfecta. The classification in these diseases has therefore been transferred to disorders in bone formation. The dysostotic lesions are not classified separately, as in RUBIN's table, and the lesions tabulated by this author under 'dystrophy' have now been classified as disorders in formation, or rebuilding of bone.

Many *lesions* that occur *in mature bone* are not late changes starting at adult age but have been caused by disorders in the growing ends of long bones and the *growing zones of short bones*. *This is true for structural changes as well as for* those in modelling. Such changes have been included as disorders in bone formation or in modelling.

Two disorders of a specific type associated with the rebuilding of mature bone are callus and necrosis of bone. In the first one a granulomatous richly vascularized tissue of high osteogenic capacity develops which is suited for restoring the osseous continuity in fractures. A bone or part of it has lost its vascular

clastic activity resulting in lacunar resorption and filling of the marrow with fibrous marrow tissue (JAFFE 1958 BOYD 1961) An overgrowth of bone known as gigantism and acromegaly occurs on the other hand in the hormonal over activity in hyperpituitarism It might also be added that toxicosis may stimulate bone growth Phosphorus poisoning in episodes in the growing subjects indicates the relative rates of growth and modelling of long and short bones (see RUBIN 1964)

The osteogenic activity in the remaining diseases is pathologically stimulated by different non osteogenic tissues Sometimes osteoblastic activity sometimes osteoclastic activity dominates as indicated by excessive production or resorption of bone Inflammation may stimulate both activities and by impairing the circulation cause necrosis of bone and sequestration Hemangiomas in general have both histologically and radiographically typical appearances Bone resorption dominates in reticulosis and there is no osteoblastic reaction Metastases like inflammation may stimulate both osteoblastic and osteoclastic activity The former is the primary feature in prostatic carcinoma as well as in the early stages of Ewing s tumour Mammary and thyroid carcinoma may stimulate both activities depending upon the degree of malignancy Bronchogenic carcinoma and hypernephroma as well as myeloma may produce metastases that act exclusively in breaking down bone

The lesions of bone are classified in this discussion as disorders in formation in growth and modelling and in rebuilding of the mature tissue Table 2 correlates the lesions to the commonly occurring osteogenic and non-osteogenic abnormal tissues

SUMMARY

A classification of bone lesions based upon the consideration of bone as a connective tissue with osteogent capacity is presented According to this classification the bone lesions are d id d into d sorders of formation modelling and rebuilding of bone

ZUSAMMENFASSUNG

Eine neue Klassifizierung der Knochenerkrankungen wird angegeben die darauf gestutzt wird dass Knochen prinzipiell als Bindegewebe mit osteogener Fahigkeit betrachtet werden muss (mass die er Klassifizierung sind die Knochenerkrankungen in Storungen der O sifikation d r Formgebung und des Umbaus eingeteilt

RÉSUMÉ

L auteur presente une cla sification des lesions osseuses basee sur le fait que l os est un tissu njon tif avant une capacite osteog nique D apres cette classification les lesions os euses s nt divisees en troubles de la formation du moulage et d la transformation d l os mur

Table 2

Pathologic features of bone

Abnormal tissues	Disorders in		
	Formation of bone	*Modelling of bone*	*Rebuilding of bone*
Fibrous	Dysfibroplasia (epi-, meta-, dia-physeal, subperiosteal), fibrosarcoma		
Chondromatous	Dyschondroplasia, chondrosarcoma	Congenital hypo- and hyperplasias and malformations (epiphyseal, physeal, metaphyseal, diaphyseal)	
Osseous	Dysosteoplasia: Hyperdysosteoplasia (localized, disseminated, circumscribed, generalized); Hypodysosteoplasia; Deforming dysosteoplasia		
Granulation			Callus
Avascular			Necrosis
Fat marrow			Osteoporosis
Fibrous marrow			Hyperparathyroid dysfibroplasia
Vasculocellular			Inflammation
Hemangiomatous			Hemangioma
Reticuloendothelial			Reticuloses
Cellular			Metastases

the osteoblastic activity and the ordinary osteoclastic activity. A reduction in the number and thickness of the trabeculae occurs and the lost bone tissue is replaced by fat marrow tissue. The reduction of bone in osteoporosis never reaches the level of a general break-down of bone, often combined with circumscribed dysfibroplasia, which may be found in the hormonal overactivity in hyperparathyroidism. The bone changes in the latter are characterized by an abnormal osteo

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PULMONARY HAEMORRHAGE IN RENAL DISEASE

by

W MORTENSSON L E LARSSON and B LINDQVIST

Pulmonary haemorrhage may occur in several diseases involving the kidneys such as nephrosclerosis glomerulonephritis periarteritis nodosa (23) Wegener s granulomatosis (19) pyelonephritis acute renal failure and myeloma (24) The most common cause is glomerulonephritis of which more than 100 cases have been reported (21) MCCAUGHEY & THOMAS at autopsy found bilateral haem orrhage in 25 out of 252 cases of glomerulonephritis and small areas of local haemorrhage and haemosiderosis in 119 cases Haemoptysis had been noted in only 22 cases

Radiographic pulmonary changes in glomerulonephritis caused by haem orrhage have been reported in 87 cases (1—3 5—11 13 14 17—20 22, 23 25—27 29—31 33—39 41 44—47 51—57) The diagnosis of pulmonary haemorrhage was based on a history of haemoptysis confirmed at autopsy in 76 cases based on haemoptysis alone in 10 cases who survived and on autopsy findings alone in one case 5 cases were confirmed by lung biopsy Iron laden macrophages in the sputum made the diagnosis probable in 9 cases The time that elapsed between roentgen examination and autopsy, when the haemorrhage

From the Roentgendiagnostic Department (Director Prof Olle Olsson) the Institute of Pathology (Director Prof C G Ahlström) and Medical Clinic B (Director Prof N Alwall) University Hospital Lund Sweden Submitted for publication 4 July 1967

was revealed, was 5 days or less in 20 cases, it was 5 to 14 days in 13 cases and more than 14 days in 39 cases Information was not available in the remainder of cases Haemoptysis from slightly blood stained sputum to massive haemorrhage was reported

The changes disclosed at the roentgen examination in these 87 cases were described as 'coarse or fine mottling', 'nodular', 'granular', 'patchy', stippling, or similar terms, in 51 cases, as 'generalized pulmonary oedema' in one case, and as 'diffuse processes', opacities and 'haziness' in 35 cases Bilateral changes were seen in 67 and unilateral ones in 13 cases, no information was given in 7 cases The changes were asymmetrical in 37 cases, predominating on one side or the other, on the right side in 30, the left in 3, and uncertain in 4 cases They were symmetrical in 24 cases and the location was not mentioned in 26 cases The upper part of the lung was involved in 26 cases, the middle part in 61 and the lower part in 46 cases Information in this respect was insufficient in 17 cases The central part of the lung adjacent to the hilum was involved in 30 cases and not involved in 25, while it was doubtful in 32 cases whether or not there was any involvement These changes extended to the periphery in 26 cases while a free peripheral zone was noted in 21 cases, information was not given in 40 cases

Twelve cases of haemoptysis have also been described in which the findings at the roentgen examination of the chest were normal but in which evidence of lung haemorrhage was disclosed at autopsy A probable explanation of this may be that the haemorrhage was small

Roentgen examination in the lateral decubitus position has been reported in only one case of pleural effusion (3) A lateral film for exact localization of the changes was obtained in one case (29) The time interval between development and disappearance of changes in 10 cases ranged from 9 to 30 days

From these collected cases it is difficult to distinguish any typical radiographic changes produced by pulmonary haemorrhage The main reasons for this seem to be that the examinations were incomplete and that a figurative indeterminate nomenclature was used Pulmonary oedema bronchopneumonia and atelectasis may in some of the cases have co existed with pulmonary haemorrhage It is impossible to decide from the published descriptions which changes were solely due to haemorrhage All the patients had renal disease most of them with some impairment of renal function, and many with uraemia of varying severity The differential diagnosis of pulmonary changes in renal disease is difficult to establish radiographically (1 6, 16, 21 28), especially in cases of uraemia but oedema bronchopneumonia and atelectasis may also occur before the uraemic stage is reached (1, 16, 28) Uraemic pulmonary oedema is quite common in severe renal disease ALWALI reported such changes in 43 % of his cases Since this

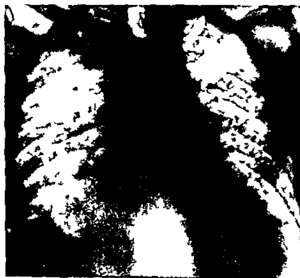


Fig 1 Case 1 Generalized poorly defined nodular changes in the lungs including the peripheral zones



Fig 2 Case Confluent poorly defined nodular changes in the lungs including the peripheral zones particularly in the basal regions

complication may prove fatal, and since it responds to adequate dehydration (1), it is important that the diagnosis should not be missed The roentgen diagnosis of lung haemorrhage will often be presumptive A report of some cases in our series that almost certainly had pulmonary haemorrhage may therefore be of interest

The series includes patients who died of renal disease in the years between 1948 and 1964 and in whom considerable pulmonary haemorrhage was evident at autopsy The whole series of cases of lung haemorrhage will be published shortly (24) We have selected for this paper 20 cases that were examined within four days of death The 4 day limit was fixed arbitrarily to reduce the differential diagnostic difficulties to some extent The presence of extensive bronchopneumonia or atelectasis could be more definitely determined at autopsy although pulmonary oedema could not be excluded

All the patients were in poor condition and could only be examined in bed

There were no pulmonary changes in eight of the 20 cases, although at autopsy 1 to 4 days later moderate to marked haemosiderosis as well as large haemorrhages in the lungs were revealed Uraemic lung oedema was present in four cases, pleural effusion was evident in one case, and in seven cases, finally other pulmonary changes were recorded

Case reports

Case 1 Male aged 56 who had had proteinuria haematuria and headaches since 1949 developed an upper respiratory tract infection with slight elevation of emperature on 18 April 1961 A week later he began to have chest pain and the next week dyspnoea No haemoptysis was present but there were dependent oedema and numerous fresh ecchymoses on his legs Blood pressure was 200/120 mm Hg NPN 254 mg per 100 ml pericardial friction rub severe retinopathy Treatment by diarrhoea inducing drugs to produce dehydration had little effect The patient died on 5 May NPN was then 361 mg per 100 ml

Roentgen examinations (bedside) on 1st and 3rd May disclosed generalized symmetrical course nodular changes in the lungs including the peripheral zones (Fig 1)

Autopsy Recent haemorrhages in the lungs haemosiderosis protein rich oedema and small areas of pneumonia partly organised with fibroblast proliferation along broad alveolar septa Nephrosclerosis partly malignant in type with signs of pyelonephritis

Case 2 Male aged 58 who developed a sore throat joint pain and fever on 15 June 1964 Penicillin treatment had no effect Haematuria and cylindruria developed a week later and dyspnoea and uraemia (NPN 175 mg per 100 ml) after another week On admission on 30 June he appeared anaemic (Hb 7 g per 100 ml) and had severe tachypnoea slight rales over the lungs He was haemodialysed seven times between 30 June and 11 July No haemoptysis or purpura was noted but he had slight bleeding from the nose and mouth He was given large doses of antibiotics and was dehydrated to the borderline of shock losing 11 kg without any beneficial effect The dehydration treatment was stopped since it had become to risky He died on 11 July

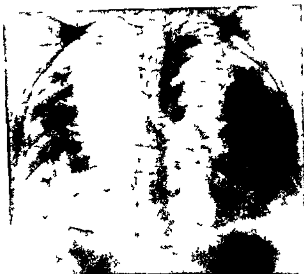


Fig 3 Case 3 Confluent nodular changes most marked in the peripheral zones



Fig 4 Case 4 Confluent nodular changes in the peripheral zone mostly on the right side

Roentgen examinations (bedside) between 30 June and 10 July revealed symmetrical generalized poorly defined nodular parenchymatous changes in the lungs including the peripheral zones (Fig 2)

Percutaneous lung biopsy on 8 July revealed much iron pigment in macrophages partly in the alveoli partly in the alveolar septa

Autopsy Massive lung haemorrhages of varying age haemosiderosis vasculitis and foci of leucocyte exudation of bronchopneumonic type Acute to subacute partly necrotizing glomerulonephritis

Case 3 Male aged 25 who developed intense headaches in February 1959 In April he began to have fatigue and rhinitis in May joint pains chills and sweating and in June conjunctivitis He was admitted to hospital on 4 July Haematuria proteinuria and a high ESR were present no haemoptysis NPN was normal on 15 July and 80 mg per 100 ml on 26 July On admission to this clinic on 27 July tracheotomy was performed because of pulmonary changes and marked dyspnoea the trachea was found to contain a small amount of blood stained secretion He was placed in the respirator and dehydration with diarrhoea inducing drugs was attempted On the night of 27 July pulmonary oedema with frothy blood stained secretion from the trachea suddenly developed and the patient died

Roentgen examination (bedside) on 8 July disclosed no abnormality but on 26 and 27 July symmetrical, partly confluent coarsely nodular changes most marked at the periphery but not extending towards the hilum had developed (Fig 3)

Autopsy Extensive recent lung haemorrhages with diffuse bronchopneumonic lesions moderate haemosiderosis fibrinous exudation and oedema Acute to subacute necrotizing glomerulonephritis with areas of periglomerulitis

Case 4 Male aged 66 a former stone cutter developed nausea and giddiness in October 1962 Sixteen years earlier he had had haemoptysis silicosis was thought likely but roentgen examination of the chest and bronchography at that time had been normal NPN was 215 mg per 100 ml in November 1962 He was admitted to our clinic on 5 November

Roentgen examination of the urinary tract revealed small kidneys He was dialysed three times between 4 and 23 November His condition deteriorated mental confusion convulsions and finally rales over the lungs appeared There was no haemoptysis The patient died on 23 November

Roentgen examination (bedside) on 22 October had revealed no abnormality Between 15 and 19 November bilateral peripheral partly confluent nodular parenchymatous changes appeared mostly on the right side These did not extent towards the left hilum (Fig 4)

Autopsy Extensive recent lung haemorrhages moderate haemosiderosis and small areas of haemorrhagic pneumonia and oedema chronic glomerulonephritis

Case 5 Female aged 14 with epilepsy since she was 4 years old who developed an upper respiratory tract infection in November 1962 Rhinitis with blood stained discharge skin purpura haematuria and proteinuria were present Increasing renal insufficiency developed in the spring She was dialysed seven times between 13 June and 30 July She had repeated attacks of dyspnoea and renal pulmonary oedema was evident at roentgen examinations Dehydration produced a weight loss of 8 kg There was no haemoptysis In the last week before death on 30 July she was increasingly restless had abdominal pain parotitis and dyspnoea



Fig 5 Case 5 a) Partly confluent nodular changes throughout the left upper lobe b) Progression on the left side changes typical of uraemic pulmonary oedema present on the right side

Roentgen examination (bedside) on 12 and 16 June showed renal pulmonary oedema which was found to have disappeared by 29 June after dehydration On 6 July there were coarse nodular changes in the left upper pulmonary lobe which persisted despite intensive dehydration (Fig 5) On 29 July further progression of the pulmonary changes (Fig 5b)

Autopsy Recent lung haemorrhages marked haemosiderosis broad alveolar septa with fibroblast proliferation fibrinous exudation and protein rich oedema no areas of pneumonia Subchronic partly necrotizing glomerulonephritis

Case 6 Female aged 50 who had eaten a poisonous mushroom (Amanita phalloides) on 25 August 1963 Within a few hours she developed weakness vomiting and muscle cramps On 28 August she was jaundiced and by 29 August anuric Thrombocyte count 13 000 Melaena developed on 30 August and haemoptysis on 1 September She was haemodialysed on 1 and 2 September but died of shock on 2 September

Roentgen examination (bedside) on 31 August showed no pulmonary changes On 1 September there were extensive parenchymatous changes basally with areas of atelectasis in the right lung a small parenchymatous lesion was observed in the left lower lobe (Fig 6)

Autopsy Extensive recent lung haemorrhages in all the pulmonary lobes as well as small areas of old haemorrhagic pneumonia Advanced renal tubular necrosis

Case 7 Male aged 56 mentally abnormal with pulmonary tuberculosis since 1958 who developed increasing shortness of breath and an intermittent dry cough in the spring of 1964 no haemoptysis By February 1965 the urinary output had begun to decrease Antibiotics were given for lung changes but these increased further He was admitted to hos



Fig 6 Case 6 Parenchymatous changes with atelectasis of the right lung Small changes basally on the left side



Fig 7 Case 7 Confluent nodular changes throughout the basal zone

pital on 24 May Dyspnoea at rest blood pressure 220/150 severe retinopathy enlargement of the heart urea nitrogen of 118 mg/100 ml and a haemoglobin concentration of 9 5 g per 100 ml were then recorded In spite of urine volumes of 1 000 to 1 900 ml the urea nitrogen ro e to a maximum of 280 mg per 100 ml on 2 June whereafter it fell again Haemoptysis occurred on 2 and 4 June The bodyweight fell slightly during the last week of his life He died on 9 June

Roentgen examination (bedside) on 17 May Bilateral diffuse nodular basal changes with old apical tuberculous lesions On ? and 5 June coarse nodular partly confluent infiltrates were observed bilaterally predominantly on the right side in addition to the previous findings The changes were mainly situated peripherally and in the lower lobes The hilar regions of the upper lobes were relatively free On 6 May no pleural effusion (Fig 7)

Autopsy Extensive recent lung haemorrhages notably in the lower lobes haemosiderosis and oedema glomerulonephritis of the membranous type

Discussion

All seven cases had roentgen pulmonary changes that differed from those usually seen in uraemic lung oedema Pulmonary oedema and bronchopneumonia were at first considered likely Increased temperature and leucocytosis were not present but these are often absent with infection in uraemia Large doses of antibiotics had no effect The subjects were in a poor condition and only one could be examined in the lateral decubitus position there was no pleural effusion Dehydration was tried in all cases (in five resulting in insignificant weight loss) The roentgen appearances were unchanged after dehydration In only one case (Case 2) could dehydration be considered to have been adequate dehydration of 11 kg approaching to borderline of shock was achieved Some degree of oedema cannot be excluded in the remainder of cases since the de hydration may have been inadequate No atelectasis was seen at autopsy and only such sparse infectious lesions that the radiographically observed changes cannot be explained by infection alone The presence of pulmonary haemorrhage is supported by the finding of large haemorrhages in the lungs at autopsy one to four days later In six cases there was also moderate to marked haem osiderosis indicating old haemorrhage Haemoptysis occurred in another three cases and in a fourth case biopsy of the lung revealed large amounts of iron pigments in the macrophages It was therefore considered most probable that the radiographically observed changes were due to haemorrhage with some degree of oedema

Roentgen examination revealed in six cases partly confluent nodular paren chymatous changes which also involved the periphery A more homogenous in filtration of the parenchyma with evidence of atelectasis was present in one

case The changes were bilateral in all the cases but in four they extended asymmetrically The upper part of the lung was involved in three cases the middle part in six and the lower part in six cases A free peripheral zone was seen in only one case, and there were central changes adjacent to the hilum in six cases, though they were very sparse in two and on the right side only The appearances of the changes were consistent with lung haemorrhage, they resembled in Cases 1 and 5 those that occur in uraemic pulmonary oedema

The role of heparinization in the causation and appearance of the pulmonary changes in the present cases is obscure

On the basis of the literature and this study it seems indicated that nodular, asymmetrical changes which extend peripherally and medio-basally, and are most marked on the right side, with only slight involvement of the hila, most probably represent pulmonary haemorrhages The description of typical changes in lung haemorrhage by BENOIT et coll as 'spreading from the hilar regions towards both bases is not generally correct A characteristic seems to be the relatively slow disappearance of the changes (over about 9 days), they have never been reported to disappear rapidly

Dehydration may help to differentiate pulmonary haemorrhage from pulmonary oedema, as illustrated by Cases 2 and 5 The absence of pleural effusion may possibly support the diagnosis of pulmonary haemorrhage, but further observations are needed Pleural effusion may, however, be absent in many cases of fluid retention lung (1)

Only some of the cases of lung haemorrhage will fulfil all the above mentioned roentgenographic criteria The finding of central bilateral changes radiating from the hila with a free peripheral zone, in uraemic pulmonary oedema is regarded as typical (4) Many exceptions have been described however, and pulmonary oedema has been observed unilaterally as well as peripherally and basally (for surveys see 1, 28) That pulmonary oedema was really present in some of these cases is evident from the fact that the changes disappeared quickly after dehydration This rapid disappearance is one factor that helps to establish the diagnosis of pulmonary oedema it may persist for a long time after inadequate dehydration (1) What makes the roentgen diagnosis of pulmonary changes in renal disease so difficult is the frequent co existence of several different processes in the lungs, besides haemorrhage there are often oedema infection, stasis, stagnation of secretion and atelectasis Moreover, the poor general condition of the patients does not permit a complete roentgenologic examination Introduction of closed lung biopsy and cytology in the examination may in future facilitate the diagnosis as in our Case 2

Minor haemorrhages need not produce roentgen changes The eight cases without pulmonary changes had nevertheless considerable haemosiderosis

SUMMARY

A survey of published reports on changes in pulmonary haemorrhage in renal disease is presented and this is supplemented with the authors twenty cases seven of which are described in detail Eight of the cases had no pulmonary changes at roentgen examination but autopsy revealed marked haemosiderosis Four cases had pulmonary oedema one had pleural effusion and seven had pulmonary changes described as and supposed to represent pulmonary haemorrhage

ZUSAMMENFASSUNG

Die Arbeit enthalt eine Literaturubersicht uber Fallen von Lungenblutungen bei Nierener krankun en Dazu kommen zwanzig eigene Falle von denen sieben eingehend beschrieben werden In acht von diesen Fallen wurden bei der Rontgenuntersuchung keine Verande rungen beobachtet aber bei Autopsie wurde starke Hamosiderose festgestellt Lungenodeme waren in vier Fallen vorhanden in einem Fall Pleuraerguss und in sieben Fallen Lungen veranderungen die vermutlich durch Lungenblutung verursacht wurden

RÉSUMÉ

Les auteurs completent une revue des publications sur les signes d hemorragie pulmonaire au cours des nephropathies par la presentation de 20 cas dont sept sont decrits en detail Huit de ces cas ne presentaient pas de signes radiologiques pulmonaires bien que l autopsie ait montre une hemosiderose marquee quatre avaient un oedeme pulmonaire un cas un epanchement pleural et sept avaient des signes pulmonaires que l on a supposes dus a une hemorragie pulmonaire et qui ont eté decrits comme tels

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case The changes were bilateral in all the cases but in four they extended asym metrically The upper part of the lung was involved in three cases, the middle part in six and the lower part in six cases A free peripheral zone was seen in only one case, and there were central changes adjacent to the hilum in six cases, though they were very sparse in two and on the right side only The appearances of the changes were *consistent with lung haemorrhage* they resembled in Cases 1 and 5 those that occur in uraemic pulmonary oedema

The role of heparinization in the causation and appearance of the pulmonary changes in the present cases is obscure

On the basis of the literature and this study it seems indicated that nodular, asymmetrical changes which extend *peripherally* and *medio basally*, *and* are most marked on the right side, with only slight involvement of the hila, most probably represent pulmonary haemorrhages The description of typical changes in lung haemorrhage by BENOIT et coll as spreading from the hilar regions towards both bases is not generally correct A characteristic seems to be the relatively slow disappearance of the changes (over about 9 days), they have never been reported to disappear rapidly

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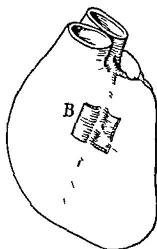


Fig 1 A cut muscle bridge (B) over the descending branch of the left coronary artery

bridges and two bends not explainable anatomically They carried out the angiographies in hearts arrested by acetylcholine

These data in the literature raise the following questions (1) whether all bends in coronary arteries seen at angiography are conditioned by the spanning of the arteries by muscle bridges or loops (2) whether the surgical division of the muscle bridges or loops would much change the angiographic appearances and (3) what microscopic changes occur after the division of a bridge

Material and Methods A total of 10 dogs weighing between 14 and 22 kg were examined The experiment was started by coronary angiography The findings were confirmed macroscopically at operation The bridges of loops were divided and the epicardium on the descending branch of the left coronary artery was freed Further coronary angiography was performed immediately following operation in one dog and from 3 to 10 days after operation in seven dogs In two dogs the examination was carried out 3 weeks 2 months and 9 months after operation The dogs were killed after the angiographic examination and the findings checked macroscopically

Technique of coronary angiography A yellow or exceptionally a green Ödman Ledin catheter was introduced into the exposed femoral artery and 15 to 25 ml Urografin 75 % (Verografin Uromiro or Urovison) were injected under a pressure of 4 to 6 atmospheres Films were obtained with an AOT film changer at a rate of 4 to 6 films/second for two seconds The examination was carried out under thiopental anaesthesia without stopping the heart

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BENDS IN THE CORONARY ARTERIES AFTER REMOVAL OF MUSCLE BRIDGES

by

O ELISKA, V SKOP and P HA[illegible]T

Numerous bends are seen in the coronary arteries of man and dog, bot macroscopically post mortem and at angiography in vivo A whole seri of factors are known to produce these bends, and the present work is concerne with how and to what extent the bends may be caused by muscle bridge Bridges were described by TANDLER as early as 1913 as muscle fibres spannin short sections of the coronary arteries The changes have been dealt witl both from the anatomic and pathologic aspects by numerous authors (2 9 10, 12, 14, 17, 18, 19 23, 27)

PORSTMANN & IWIG (1960) worked on the problem from the aspect o function and at coronary angiography in man noted systolic narrowing o the left coronary artery at the site where it was covered by a muscle bridge POLACEK et coll (1962) demonstrated biphasic curving and slight narrowing of the artery near the bridge in dogs and goats The angiographic findings were confirmed anatomically LOWMAN & BLOOR (1962) carried out a similar experiment in 32 dogs but demonstrated only two coronary arteries bent by

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The left lateral projection was used in all but one dog in which two projections were employed In view of the unimportance of the a p projection for examining the left coronary artery, this was subsequently omitted

Surgical technique Thoracotomy was carried out in all dogs via the fifth interspace, the pericardium being incised and muscle bridges cut if any were present on the descending branch of the left coronary artery (Fig 1) If no bridges were present but bending of the artery was evident at coronary angiography the epicardium was incised for 1 to 2 cm over the artery The corresponding muscle bridges and epicardium were examined histologically The right coronary artery was inspected in the right atrioventricular groove, this artery was not subjected to surgery

Histologic technique After killing the dog a section of artery was removed at the site where the bridge or epicardium had been cut After fixation in 10 % formalin the histologic sections were stained for elastin with resorcin fuchsin by the Masson method

Results

Findings in the descending branch of the left coronary artery Five of the 10 dogs examined (50 per cent) were found to have muscle bridges at operation These were present over the descending branch of the left coronary artery for a distance of 1 to 3 cm Three muscle bridges with a gap of about 3 mm between them were seen in one of these dogs Preoperative coronary angiography in all dogs with bridges during systole disclosed biphase curves on the artery at the site of the bridge

Postoperative check up of dogs with bridges indicated that the bend in the artery was always smaller after they had been cut Dog 3 is given as an example Biphase curving of the descending branch (Fig 2a) was present at the preoperative angiographic examination Fourteen days thereafter the muscle bridge was cut for a distance of 1 cm Further examination half an hour after the operation revealed diminished bending of the artery (Fig 2b) Three and nine months later the bending still persisted but the curve was flatter than before the operation (Fig 2c)

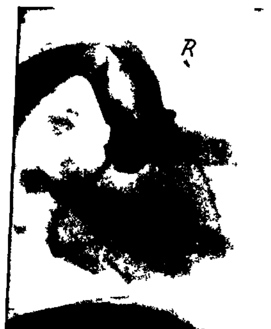
Muscle bridges over the artery were not present at operation in the remaining five dogs Despite this biphase curves suggesting the presence of bridges were evident in the preoperative angiograms This could be explained as follows In one dog this bend may have been caused by an accompanying vein which crossed the artery at this site (Fig 4 a and b) In another dog



a



b



c

Fig 2 Dog 3 Preoperative coronary angiography Biphase bend (T) in the descending branch at the site of forking of a fairly large branch b) Examination immediately after division of the bridge bend (T) still present in the descending branch right coronary artery (R) tortuous c) Nine months after operation Biphase curve (T) still present in the left coronary artery tortuous right coronary artery(R)



Fig 4 D g 6 a) Two b ph bend (T) n the descend ng branch of the left coronary artery (At ope tion the artery was found to be c ossed by a n at the site of the b nd the pe ca dium w s cis d) The catheter s s tuated between the ao t al es b) One we k later A bend (T) s st ll pres nt in th de cend ng branch

without bridges a vessel branch was seen both when the artery was spanned by a bridge and when it was free (Figs 2a 2c and 3a) Side branches of the descending branch running into the myocardium are probably the sites of firmer fixation and cause bending of the coronary artery

Findings in the right coronary artery Bends in the right coronary artery were present in the preoperative coronary angiographies in all the dogs (Figs 2b 2c 3a 3b) No muscle bridges or loops were ever seen at operation This finding is in accord with the anatomical findings of Polacek & Audrlickaja (1961) and Zechmeister (1965)

Summarizing the results of the present experiments it could be observed that the surgical division of the bridges led to a decrease in the bending of the artery It further became clear that not all bends in the coronary arteries were conditioned by muscle bridges or loops

Microscopy The microscopic findings in dogs with bridges at operation were in accord with the macroscopic appearances The excised parts of

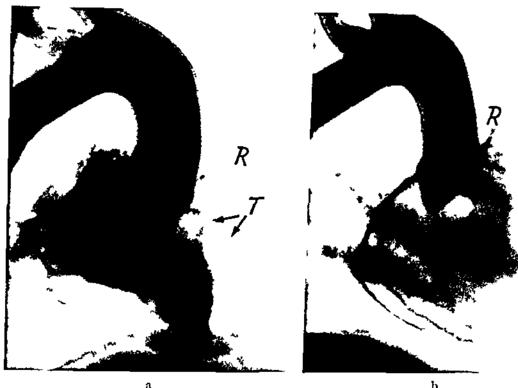


Fig 3 Dog 7 a) Preoperative examination Catheter introduced into the left ventricle Two biphase bends (T) in the descending branch of the left coronary artery right coronary artery (R) with numerous bends (No bridges over the left artery were found at operation incision of the epicardium at the site of the bend) b) Three weeks after operation No bends in the left coronary artery the tortuosity of the right coronary artery (R) persists

the catheter was situated between the valves, or in the cavity of the left ventricle, at *preoperative coronary angiography (Fig 3a) At the second examina*tion, carried out with the correct technique no bend in the descending branch could be seen (Fig 3b) The bend had probably been caused by irritation of the endocardium from the catheter or the contrast medium Bends produced in this manner must be unusual, since they were not observed in other cases in which the same technical error had been made

No explanation can be given for the presence of a bend in dog 3 of this group It is impossible to determine whether the bend had been produced by fixation of the epicardium or by a branch holding the coronary artery In the group of dogs in which no bridges were found the epicardium was incised over the artery at the site of the angiographically visible bend Postoperative control suggested that the bend was either about the same or a biphase curve had changed into a uniphase curve or had disappeared At the site of most bends demonstrated angiographically in the group of dogs with bridges and

On the other hand the objection that such scarring could explain the persistence of bends after operation is not convincing since in these experiments persistence of bends was observed on coronary angiography as early as half an hour after operation i e at a time when scars could not have developed (Fig 2b)

Discussion

No agreement on the incidence of muscle bridges yet exists They occurred over the stem of the descending branch of the left coronary artery in 50 per cent of dogs in the present material These figures differ only slightly from those of ZECHMEISTER who reported bridges over this branch in 60 per cent of his series The present investigations were always carried out on the main stem this is situated in the anterior interventricular groove which is easily evaluated by angiography In accord with POLACEK & AUDRLICKAJA, and ZECHMEISTER bridges were never observed over the right coronary artery in the right atrioventricular groove If it is assumed that bends in the coronary arteries be caused only by muscle bridges the previous findings would make it unlikely that they could have been prominent in the right coronary artery Bends were however present in this artery in all the dogs This suggests that other factors may cause bends in the coronary arteries of which the following may be considered

BOUCEK et coll (1963 1964 1965) reported that the aorta and both coronary arteries rotate from right to left during systole This movement involves only the proximal part of the right coronary artery its dorsal part on the margo acutus together with the right edge of the heart rotating in the opposite direction The right coronary artery elongates during systole and bends occur between its commencement and the site of fixation of its arterial branches (conal and sinus node arteries) at all phases of the cardiac cycle

It is known from the works of WHITTEN (1930) BARNES & WHITTEN (1929) and BOUCEK et coll that bends in the left coronary artery may be caused by the fixation of a certain part of the artery between two immovable points representing branches running into the depth of the myocardium These branches act as anchors for the free artery Bends caused by this anatomical factor mainly occur in the left coronary artery In the right coronary artery similar bends occur only in those parts of the artery that supply the left ventricle OBRUCNÍK (1956) similarly observed *S shaped* bends at the sites of perforation of myocardial muscle bundles by coronary artery branches

The present results confirm these data and also indicate that there is always a side branch near a muscle bridge The question thus arises as to

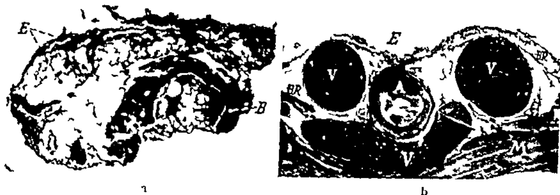


Fig 5 a) Dog 3 Resected part of epicardium (E) with muscle bridge (B) b) Dog 3 Slight fibrosis of epicardium over the descending branch at the site of removal of bridge c) Dog 5 Massive fibrosis and adhesions of epicardium and pericardium over the artery after excision of the bridge
A — artery BR — edge of bridge E — epicardium F — fibrosis M — myocardium O — branching off of smaller artery V (in dog 3) veins filled with mixture of barium sulphate and minimum in 7 gelatine V (in dog 5) — vein



epicardium with a bridge had a thicker layer of muscle fibres running under the epicardium (Fig 5a) The macroscopic absence of muscle bridges was confirmed histologically in the structure of the epicardial tissue excised at operation

Adhesions between the epicardium and the pericardium developed at the site of operation in all the dogs The remains of their edges were apparent in the histologic preparations in the regions where the muscle bridges were divided (Fig 5, b and c) Above and lateral to the artery productive pericarditis with occasional granulomas were present (In one case reaction around the suture of a small branching vein was observed and in another case probable reaction around a small haematoma) Cicatrizing granulation tissue was not of the same degree in all the cases, transitions from fibrosis (Fig 5b) to definite scarring (Fig 5c) being seen Fibrous changes were more marked in dogs examined early (one week to one month after operation) than in those with a longer interval after operation (three to nine months) The microscopic findings suggested that division of the bridges probably has no preventive value on account of the possibility of cicatrization

ZUSAMMENFASSUNG

Die Koronargefasse wurden angiographisch in zehn Hunden dargestellt um zu untersuchen ob Muskelbrucken die zahlreichen Biegungen der Koronararterien verursachen die sowohl beim Hund als auch beim Menschen vorkommen Die Muskelbrucken wurden wahrend der Operation konfirmiert und zerschnitten Es scheint jedoch als ob auch andere Faktoren als Brucken die Biegungen verursachen konnen

RÉSUMÉ

Les auteurs ont fait des angiographies coronaires sur dix chiens pour determiner dans quelle mesure les ponts musculaires sont la cause des nombreuses courbures des artères coronaires chez le chien comme chez l homme Les résultats de ces angiographies ont éte confirmés par opération et les ponts ont eté coupés Les auteurs pensent que ces courbures peuvent être dues a d autres facteurs que la présence de ponts

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the factor involved in the bending of the artery in the region of the bridge The present observations suggest that both the bridge and the fixation by the branch are involved, since after dividing the bridge in this material, the bend diminished, although it never disappeared completely (Figs 2a, 2c, 3a, 5c)

According to LEIRICH, DE LA CHAPELLE & COHN (1931) a further known factor involved in the bending of the coronary arteries is their elongation during life SCHAFER (1932) stated that two factors, in addition to arteriosclerosis, contribute to the tortuosity of the coronary arteries In decrease of the cardiac musculature due to atrophy, rupture of the internal elastic lamina occurs from increased pressure of the pulse wave, and this leads to tortuosity of the arteries Microscopy excluded these arteriosclerotic changes in the present material in which the dogs were young

Consideration should also be given to the 'intramural forces' described by BOUCEK et coll and produced by contraction of the muscle bundles of the media of the coronary arteries They are also likely to play a part in the development of intimal changes The specific arrangement of these bundles in the descending branch supports the movements of the vessel in its longitudinal and lateral directions

Conclusion

Muscle bridges over the stem of the descending branch of the left coronary artery were present in 50 per cent of the dogs Bending of the artery was demonstrated angiographically at the site of the bridges The surgical division of the bridges failed to lead to the disappearance of uni or biphase curving of the artery but only to a decrease

Several explanations for the bends on the artery are offered, viz (1) muscle bridges, (2) crossing of the artery by a vein, (3) an imperfect angiographic technique, (4) chemical irritation of the endocardium of the left ventricle, and (5) branching of a vessel

SUMMARY

Coronary angiography was performed in a series of 10 dogs to determine the extent to which muscle bridges may cause the numerous bends occurring in the coronary arteries of dog as well as man The findings were confirmed and the bridges divided at operation It is suggested that not only bridges but also other factors than the presence of bridges may cause the bends

ZUSAMMENFASSUNG

Die Koronargefässe wurden angiographisch in zehn Hunden dargestellt um zu untersuchen ob Muskelbrucken die zahlreichen Biegungen der Koronararterien verursachen die sowohl beim Hund als auch beim Menschen vorkommen Die Muskelbrucken wurden wahrend der Operation konfirmiert und zerschnitten Es scheint jedoch als ob auch andere Faktoren als Brucken die Biegungen verursachen konnen

RESUMÉ

Les auteurs ont fait des angiographies coronaires sur dix chiens pour determiner dans quelle mesure les ponts musculaires sont la cause des nombreuses courbures des arteres coronaires chez le chien comme chez l homme Les résultats de ces angiographies ont été confirmés par opération et les ponts ont eté coupés Les auteurs pensent que ces courbures peuvent etre dues a d autres facteurs que la présence de ponts

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the factor involved in the bending of the artery in the region of the bridge The present observations suggest that both the bridge and the fixation by the branch are involved, since after dividing the bridge in this material, the bend diminished, although it never disappeared completely (Figs 2a, 2c, 3a, 5c)

According to EHRICH, DE LA CHAPELLE & COHN (1931) a further known factor involved in the bending of the coronary arteries is their elongation during life SCHAFER (1932) stated that two factors, in addition to arteriosclerosis, contribute to the tortuosity of the coronary arteries In decrease of the cardiac musculature due to atrophy rupture of the internal elastic lamina occurs from increased pressure of the pulse wave and this leads to tortuosity of the arteries Microscopy excluded these arteriosclerotic changes in the present material in which the dogs were young

Consideration should also be given to the 'intramural forces' described by BOUCEK et coll and produced by contraction of the muscle bundles of the media of the coronary arteries They are also likely to play a part in the development of intimal changes The specific arrangement of these bundles in the descending branch supports the movements of the vessel in its longitudinal and lateral directions

Conclusion

Muscle bridges over the stem of the descending branch of the left coronary artery were present in 50 per cent of the dogs Bending of the artery was demonstrated angiographically at the site of the bridges The surgical division of the bridges failed to lead to the disappearance of uni or biphase curving of the artery but only to a decrease

Several explanations for the bends on the artery are offered, viz (1) muscle bridges, (2) crossing of the artery by a vein, (3) an imperfect angiographic technique, (4) chemical irritation of the endocardium of the left ventricle and (5) branching of a vessel

SUMMARY

Coronary angiography was performed in a series of 10 dogs to determine the extent to which muscle bridges may cause the numerous bends occurring in the coronary arteries of dog as well as man The findings were confirmed and the bridges divided at operation It is suggested that not only bridges but also other factors than the presence of bridges may cause the bends

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DRAINAGE OF RADIOGRAPHIC CONTRAST MEDIA FROM THE ABDOMINAL CAVITY

Experimental studies in rats

by

ILMARI LINDGREN EVA J NAGY and PEKKA VIRTAMA

Injection of radiographic contrast media into the peritoneal cavity coeliography has not gained wide clinical acceptance although it has been used in a number of experimental examinations in laboratory animals (MARGULIS et coll 1963) This probably is due to the fact that an ideal and harmless medium is not as yet available

Large quantities of fluid amounting to up to 30 per cent of the body weight can be absorbed from the peritoneal cavity (KRUGER et coll 1962) Contrast media of molecular particle size disappear rapidly from the peritoneal cavity apparently via the chylous cistern and proceed to the parasternal lymphatic channels and to the lymphatic glands of the neck and filling of the thoracic duct is negligible (MENVILLE 1932 POMERANZ 1934 OLIN & SALDEEN 1964) Thus injection of a colloidal solution of thorium dioxide (Thorotrast) offers a possibility of demonstrating the lymphatic channels leading from the peritoneal cavity to the mediastinum KOEHLER (1965) used iodized oil in similar experiments

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After some preliminary experiments 0 1 and 0 25 ml of the contrast media were used for each injection The following media were tested Thorotrast 25 % (Fellows Testagar), Micropaque (Damancy Ltd) in a 10 % suspension in physiologic saline zirconium oxide (BDH) in a 10 % suspension in physiologic saline Dionosil Aqueous (Glaxo Ltd) Isopaque (Nyco AB), Solu Biloptin (Schering) Urografin (Schering), and Perjodal H (Pharmacia AB)

The animals were examined with an Elema Schonander unit, the roentgen tube being fitted with a 0 5 mm tungsten target and a 0 5 mm beryllium window The tube tension was 40 kV and the exposure time about 0 3 seconds at a distance of 1 meter Kodak non screen roentgen film (Kodirex) was used The animals were examined immediately after the intraperitoneal injection so as to ascertain that the material injected had reached the peritoneal cavity Films were obtained at 2 and 10 hours and then 2 5 7 21 and 32 days after the injection

Each series consisted of at least 18 experimental animals and these were sacrificed at different intervals depending on the time of disappearance of the medium If any contrast medium was visible outside the peritoneal cavity, dissection was performed immediately and the organs were roentgen examined by the above technique Microradiography and histologic studies were also employed so as to examine the pathways of the different contrast media The freezing technique was applied when oily media were used

Resorption of the barium sulphate suspension from the peritoneal cavity was also investigated with the aid of an isotope technique Barium sulphate was administered either as $^{140}BaSO_4$ or as $Ba^{35}SO_4$

The $^{140}BaSO_4$ (300 μCi) was injected intraperitoneally and the animals were examined scintigraphically every other day The animals injected with $Ba^{35}SO_4$ were dissected between 1 and 7 days after the injection The organs of the thoracic cavity diaphragm liver and omentum were examined autoradiographically (Kodak AR 10 stripping film exposure time from 40 hours to 35 days)

Various organs were incubated in 20 ml NaOH 2 % each for 18 hours at 37 C then evaporated on a water bath for one hour The activity was measured by means of a methane flow counter

Results

Dionosil Isopaque Solu Biloptin Perjodal and Urografin disappeared from the peritoneal cavity within 1 to 4 hours In none of the cases could the media be found in any other organs

Thorotrast appeared radiographically at 2 to 3 days in the lymphatic chan



Fig. 1. Rat. 2 days after injection of 0.1 ml Thorotrast. Lymphatic vessels and nodes are visible in the thorax and neck.

The first research workers studying the lymphatic drainage of the peritoneal cavity found that granules of India ink and other corpuscular elements were mainly resorbed in the part covering the diaphragm. CUNNINGHAM (1922) explained that this depends on the absence of the basal membrane of the peritoneum in this region.

Contrast media containing barium sulphate particles yield good radiographic contrast but cause peritoneal adhesions. This causes death of laboratory animals in a few weeks (KAY & CHOY 1955, COCHRAN et coll. 1963, KLEINWASSER & WARSHAW 1952, DORR et coll. 1964). Barium sulphate particles may in exceptional cases be demonstrated outside the peritoneal cavity (KAY & CHOY).

The purpose of the present work was to examine the resorption of various roentgen contrast media from the peritoneal cavity with special regard to their particle size. This is both of theoretical interest and of importance in clinical coeliacography.

Material and Methods. Wistar rats of both sexes, weighing about 200 g, were used as experimental animals. The contrast media were injected under general anaesthesia.



Fig 3 Local enla gem ent of fig 2 a Am phous material (Th orotrast) in the marginal sinus and in th cytoplasm of macrophages × 300

the left part of the peritoneal cavity was present at the site of injection for some 12 hours (Fig 4 a and b) and then moved slowly to the right side of the diaphragm to appear in the region of the liver (Fig 4 c) Total body scinti grams disclosed that a small part of the barium suspension was present in the upper mediastinum 4 to 8 days after the injection (see Fig 4 d)

The following activities were measured in 0 05 ml of the homogenized organs after intraperitoneal injections of $Ba^{35}SO$ lungs 0 heart 0 liver 0 medias tinum 1 300 impulses/min In addition an activity of 750 impulses/min was measured at the diaphragm apparently due to adherent barium sulphate granules

Conclusions

Particulate contrast media injected into the peritoneal cavity are partially absorbed via the lymphatic system The diaphragmatic part of the peritoneum plays an important role in the process Thorotrast made it possible to demon strate the efferent lymphatic channels of the peritoneal cavity The dosage used in this study was much smaller than that employed previously i e only



Fig 2 A lymph node containing a large amount of Thorotrast appears more clearly in the microradiogram (b) than in the conventional histologic section (a) (× 20)

nels of the diaphragm and the mediastinum, and in the lymphatic glands of the neck at one week (Fig 1) With an injection of 0 1 ml it was seen only in the lymphatic channels, due apparently to the dilution of the contrast medium in the peritoneal cavity Histologically, however, Thorotrast was always demonstrated in the lymphatic glands of the neck It was situated in the cytoplasm of the macrophages or in the marginal sinus of the lymphatic nodes (Figs 2 and 3)

Lipiodol remained in the peritoneal cavity for 8 to 10 days and persisted for 30 days in the lymphatic channels of the mediastinum and the diaphragm Histologically, it was possible to show that this medium was collected by the lymphatic system

Barium sulphate and zirconium oxide remained in the peritoneal cavity up to 60 days Neither appeared outside the peritoneal cavity Intraperitoneal adhesions always occurred after 20 days

Scintigraphic studies revealed that a $^{140}BaSO_4$ suspension introduced into



Fig 3 Local enl gement of f g ? a Amorphous mater al (Thorotrast) in the ma ginal s nus and in the cytopla m of macrophage × 300

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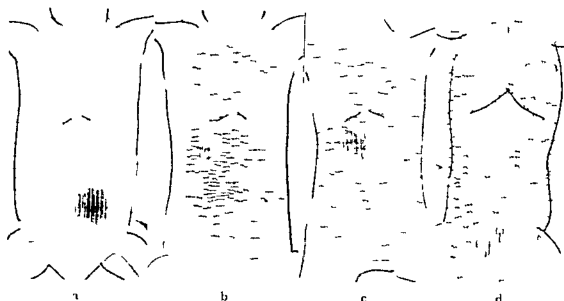


Fig 4 Scintigrams of rat (Siemens Nukleograph) a) Immediately after intraperitoneal administration of a 300 μCi ^{14}BaSO suspension (0 8 ml) The activity is seen at the site of injection b) At 72 hours after administration of the radioactive barium suspension The material has left the site of injection and is located to the right side of the abdominal cavity a considerable proportion has migrated towards the right diaphragm and appears in the liver c) At 8 days after the intraperitoneal administration All of the radioactive barium suspension has moved to the area beneath the right diaphragm d) Scintigram of rat 4 days after administration of ^{140}BaSO (300 μCi) Part of the barium suspension appeared in the lesser pelvis or on the right side of the abdominal cavity a considerable quantity of the suspension that did not dissolve in the water migrated into the superior mediastinum

0 1 and 0 25 ml, corresponding to 35 to 90 ml in man The radioactivity of Thorotrast precludes its clinical use, however

Lipiodol (Ethiodol) is also absorbed to such an extent that it is possible to demonstrate the peritoneal cavity and its efferent lymphatic channels, even if the contrast medium remains up to 30 days It is uncertain if amounts large enough for the examination of the entire peritoneal cavity and its diaphragmatic and mediastinal lymphatic channels can be administered to human subjects

The behaviour of a radioactive barium sulphate suspension is mainly of theoretical interest, because due to foreign body irritation and the production of adhesions, it cannot be injected into the peritoneal cavity This medium enters the diaphragmatic and mediastinal lymphatic channels only to a small extent It is apparent that contrast media containing large particles are resorbed slowly and only to a slight degree

Acknowledgement

This work was supported by a grant from the Sigrid Juselius Fund

SUMMARY

The resorption and other effects of different water soluble oily and particulate contrast media were examined after intraperitoneal injections in rats Barium sulphate could not be demonstrated radiologically outside the peritoneal cavity but scintigraphy revealed small amounts of labelled barium sulphate in the mediastinal channels Thorotrast was rapidly absorbed Lipiodol was more slowly absorbed and could be demonstrated radiologically in the mediastinal lymphatic channels

ZUSAMMENFASSUNG

Verschiedene wasserlosliche olige und kolloidale Kontrastmittel wurden intraperitoneal in Ratten injiciert und deren Resorption und andere Effekte wurden studiert Kein Barium sulphat konnte rontgenologisch ausserhalb der Peritonaalhohle demonstriert werden aber szintillographische Untersuchungen zeigten dass kleine Mengen von radioaktivem Barium ihren Weg in die Lymphgefasse des Mediastinums fanden Thorotrast wurde schnell absor biert Lipiodol wurde langsamer absorbiert und konnte rontgenographisch in den Lymph gefassen des Mediastinums demonstriert werden

RÉSUMÉ

Les auteurs ont étudié la résorption et les autres effets de différents moyens de contrast hydrosolubles huileux et en particules solides apres injection intrapéritoneale sur des rats Ils n ont pu démontrer radiologiquement la presence de sulfate de baryum hors de la cavité péritoneale mais la scintigraphie a montré la présence de petites quantités de sulfate de baryum marqué dans les canaux lymphatiques médiastinaux Thorotrast était rapidement absorbé Lipiodol était moins rapidement absorbé et pouvait etre démontré radiologiquement dans les canaux lymphatiques médiastinaux

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BRADYCARDIAL REACTIONS IN CEREBRAL ANGIOGRAPHY INDUCED BY SODIUM AND METHYLGLUCAMINE IOTHALAMATE (CONRAY)

Comparison with Urografin in a controlled study in man

by

G Tornell

Recent investigations by Vosse (1960) Van de Berg (1962) Fischer et coll (1961 1965) Fujii et coll (1963) Kodama et coll (1963) Gensini et coll (1964) Gottlob et coll (1965) and Hilal (1966) have indicated that the methylglucamine salts should be less toxic than the sodium salts of otherwise identical contrast media The studies now mentioned were made in animals Sjögren (1957) Fischer et coll (1962) Greitz et coll (1964 1966) studied the bradycardial reaction during carotid angiography in man and arrived at the same conclusions Fischer et coll in man compared different contrast media having the same iodine concentration Hypaque 50 % (sodium diatrizoate) and Renografin 60 % (13 2 % sodium diatrizoate and 86 8 % methylglucamine diatrizoate) Both media were injected twice in each patient with a total of four injections Of 43 separate *injections* 15 abnormal responses were noted The sequence of injection of the two solutions was at random The ECG and blood pressure were recorded The methylglucamine salt appeared to be less toxic than the sodium salt The same authors (1965) confirmed these results with

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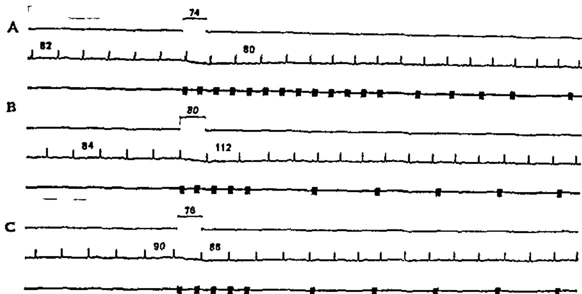


Fig 1 Recording of injection time ECG and roentgen exposures following three separate intracarotid injections in one and the same patient The three different contrast media were methylglucamine iothalamate (A) sodium iothalamate (B) and diatrizoate (Urografin) (C) The figures indicate the time in 1/100 second There was a marked bradycardial reaction after injection of the pure sodium salt in spite of the slightly longer injection time

iothalamate in animals GREITZ et coll (1964) made a controlled study of bradycardia during carotid angiography in a series of patients and a statistical analysis of the results was made The method was found to be a simple and sensitive one for comparing different contrast media

The aim of the present investigation was to make a comparison in human subjects between the pure methylglucamine and sodium salts of one and the same medium Iothalamate (Conray) was chosen for this comparison Sodium methylglucamine diatrizoate (Urografin) was also included in the study since this medium has been used in routine work for a long time

Material and Methods The material consists of thirty consecutive patients referred for carotid angiography Patients examined under general anesthesia and those with cardiac arrhythmia were not included in the study Pethidine and atropine were used for premedication, the amount of atropine being always 0 5 mg The contrast medium was injected with an automatic syringe through a percutaneous needle into the internal or into the common carotid artery ECG, roentgen exposures and injection time were recorded in all instances

The method of investigation was largely the same as in a previous study (GREITZ & TORNELL 1964) The following three contrast media were used for

Table 1

Bradycardia expressed as maximal prolongation of the heart cycle in sec/100 and injection time in seconds on intracarotid injections of three different contrast media Na = sodium as per cent of total salts M = methylglucamine as per cent of total salts (according to LINDGREN SALTZMAN & TÖRNELL 1967)

Number of patients = 30	Diatrizoate Na 13 2 M 86 8 (Urografin 60) 291 mg/ml iodine		Iothalamate M 100 (Conray 61 5) 290 mg/ml iodine		Iothalamate Na 100 (Angio-Conray 48 5)* 290 mg/ml iodine	
	Bradycardia	Injec time	Bradycardia	Injec time	Bradycardia	Injec time
Range	0—34	0 74—1 68	0—14	0 74—1 74	0—76	0 76—1 40
Mean	4 9	1 07	1 8	1 08	9 9	1 14
Patients with reaction > 4	23		10		40	

* Special concentration for this investigation

all the patients sodium iothalamate (Angio-Conray diluted to 48 5 %) methyl glucamine iothalamate (Conray 61 5 %) and sodium methylglucamine diatrizoate (Urografin 60 %) The iodine content in the first two preparations was 290 mg ml in the diatrizoate preparation it was 291 mg/ml Five milliliters of the contrast medium was used at each injection The pressure was 6 kg per cm when sodium iothalamate was used applying a cisal injector syringe with the other more viscous media the pressure was raised to 7 kg per cm which was enough to avoid a prolonged injection time

Five series were represented in this experimental investigation each comprising all six possible combinations of the order in which the different media could be

Table 2

Tachycardia expressed as maximal shortening of the heart cycle in sec/100 on intracarotid injections of three different contrast media Mean values in 30 patients Na = sodium as per cent of total salts M = methylglucamine as per cent of total salts

Contrast medium	Diatrizoate Na 13 2/M 86 8 (Urografin) 60	Iothalamate M 100 (Conray) 61 5	Iothalamate Na 100 (Angio-Conray) 48 5 %
Mean values	7 4	7 5	7 6
Range	0—27	0—20	0—38
Patients with reaction 4	60	60	57%

Table 3

Bradycardial and tachycardial reactions at intracarotid contrast injections correlated to the order of injections given

	Bradycardia expressed as maximal prolongation of heart cycle in sec/100			Tachycardia expressed as maximal shortening of heart cycle in sec/100		
Injection number	1	2	3	1	2	3
Mean of 30 patients	*5.8*	3.5	7.3	*8.3*	7.0	7.1
Range	0—34	0—28	0—76	0—38	0—22	0—20
Patients with reaction >4	33%	20%	20%	60%	53%	63%

injected. The sequence in which the total number of thirty combinations were applied was completely at random.

An attempt was made to measure bradycardia as well as tachycardia. The degree of bradycardia was expressed as the difference in hundredths of a second between the longest heart cycle after and the longest heart cycle immediately before the injection (Fig. 1). The tachycardia was measured as the difference between the shortest cycle before and the shortest cycle after the injection. The five beats prior to injection were measured. Bradycardia usually occurred within 10 seconds after starting the injection. The ECG was recorded for 30 seconds after the end of the injection.

An attempt was also made to compare the degree of discomfort experienced by the patients on injection of the different media. The patients were asked to describe the discomfort at each injection and compare with injections already given. For practical reasons this could not be done as a double blind test. The result was expressed as ranks and an analysis of variance was applied to the ranks obtained.

In one patient 5 ml of sodium chloride 4.65 %, i.e. with the same sodium concentration as in Angio Conray 50 %, or in Hypaque 50 %, were injected by hand, and the same patient was also given Urografin 60 % methylglucamine diatrizoate 60 %, sodium diatrizoate (Hypaque) 50 %, physiologic saline and hypertonic sodium chloride 2.3 % and 3.5 %.

Results

The results are given in Tables 1 to 4.

The bradycardial reaction to methylglucamine iothalamate (mean of 30 patients 1.8) was considerably less than that for the sodium salt (mean 9.9)

Table 4

Mean bradycardial and tachycardial reactions at carotid angiography in correlation to injected vessel

Contrast medium	Injections nto the internal carot d artery in 18 pat ents			Injections into the common carotid artery in 12 patients		
	Bradycardia		Tachycard a	Bradycardia		Tachycardia
	Mean	Per cent with reac tion >4	Mean	Mean	Per cent with reac tion >4	Mean
D atrizoate Na 13 2/M 86 8 (Urografin) 60	6 2	22	(8 8)	2 8	16	(5 3)
Iothalamate M 100 (Con ray) 61 5	2 1	11	(8 2)	1 3	8	(6 3)
Iothalamate Na 100 (Ang o-Con ay) 48 5	8 9	39	(8 7)	11 5	42	(6 0)
Mean total react on of bradyca dia	17 2	24	(25 7)	15 7	22	(17 6)

(Table 1) A prolongation of the heart cycle up to 4 hundredths of a second is a weak bradycardial reaction that cannot generally be distinguished from normal and respiratory variations in heart rhythm When considering only the brady cardial reactions > 4 such reactions were demonstrated in only three out of thirty cases i e 10 % when methylglucamine iothalamate was injected the three values being 6 6 and 14 Sodium iothalamate on the other hand gave 40 % of reactions > 4 ranging from 6 to 76

A statistical analysis was performed by Mr Erik Leander Lecturer in Statistics at the University of Stockholm The analysis of the original untransformed data indicated that the difference between methylglucamine and sodium iothala mate was significant at the one per cent level Urografin the mixture of a small amount of sodium and a large amount of methylglucamine diatrizoate had a position between the two iothalamate compounds In 23 % of the injections a bradycardial reaction > 4 ranging from 8 to 34 occurred A significant dif ference between Urografin and sodium iothalamate (Angio-Conray) was evident at the 5 % level the difference between Urografin and methylglucamine iothala mate Conray) was not statistically significant

Table 1 indicates that the bradycardial reaction with Urografin was more

Table 3

Bradycardial and tachycardial reactions at intracarotid contrast injections correlated to the order of injections given

	Bradycardia expressed as maximal prolongation of heart cycle in sec/100			Tachycardia expressed as maximal shortening of heart cycle in sec/100		
Injection number	1	2	3	1	2	3
Mean of 30 patients	5 8	3 5	7 3	8 3	7 0	7 1
Range	0—34	0—28	0—16	0—38	0—22	0—20
Patients with reaction >4	33 %	20 %	20 %	60%	53%	63 %

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An attempt was also made to compare the degree of discomfort experienced by the patients on injection of the different media The patients were asked to describe the discomfort at each injection and compare with injections already *given For practical reasons, this could not be done as a double blind test* The result was expressed as ranks, and an analysis of variance was applied to the ranks obtained

In one patient, 5 ml of sodium chloride 4 65 %, i e with the same sodium concentration as in Angio Conray 50 %, or in Hypaque 50 % were injected by hand and the same patient was also given Urografin 60 %, methylglucamine diatrizoate 60 %, sodium diatrizoate (Hypaque) 50 %, physiologic saline, and hypertonic sodium chloride *2 3 % and 3 5 %*

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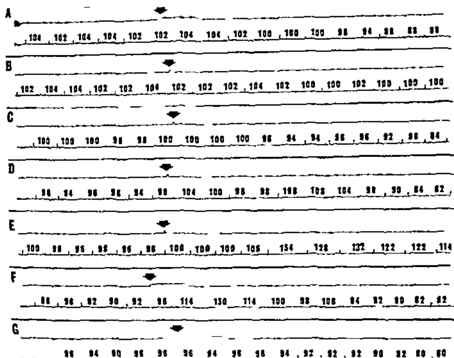


Fig 2 Effects of hypertonic saline on the heart rhythm Arrows indicate start of injections figures give the length of each heart cycle in 1/100 second Intracarotid injections of 5 ml of each one of the following contrast media were made in one and the same patient
Methylglucamine diatrizoate 60 (A)
NaCl 0 9 % (B) 2 3 % (C) 3 5 (D) and 4 65 % (E)
Sodium diatrizoate 50 % (Hypaque) (F)
Sodium methylglucamine diatrizoate 60 % (Urografin) (G)
There was a marked bradycardial reaction after injection of NaCl 4 65 and Hypaque 50 % but no bradycardial reaction after the methylglucamine compounds

Discussion

Many comparisons of contrast media as regards discomfort and complications have been published The impression from the present material is that a record of the bradycardial reactions is not only more reliable than the evaluation of subjective discomfort but also more sensitive Comparison through evaluating the subjective discomfort noted by the patient after injections of the different media did not give any significant differences in this rather small series

The bradycardial reaction during carotid angiography was first observed with other now rarely used contrast media namely iodopyracet and sodium acetri

marked in this material than in a previous study (GREITZ et coll 1964) The number of reactions larger than 4 in the present investigation was 23 % (mean reaction 4 9) with Urografin, in the previous investigation of 1964 it was 8 % (mean 1 8) This could be due to individual differences in the two series, or to statistical chance fluctuations The most probable explanation is however the *shortening of the injection time*, since the pressure had been raised, from 6 in the previous to 7 kg per cm in the present investigation This shorter injection time *may have caused increased reactions* If this supposition is correct, the difference between sodium and methylglucamine iothalamates (Table 1) with regard to bradycardial *reactions would tend to increase* rather than decrease, with due consideration of differences in injection times The mean injection time was 1 08 seconds *for methylglucamine iothalamate In spite of the longer injection* time for the sodium salt (1 14 seconds), due to the application of a lower injection pressure, the bradycardial reaction was greater As to tachycardial reactions, no differences between the three contrast media were observed (Table 2) nor were any significant differences recorded with regard to the order of injections given to one and the same patient (Table 3) Injection into the common carotid artery was performed in 12 patients, and into the internal carotid artery in 18 patients Injection into the common carotid provoked a smaller bradycardial reaction than did injections into the internal carotid artery, the mean value being 15 7 and 17 2 (Table 4), in agreement with earlier findings (GREITZ & TORNELL 1964) Contrary to this tendency, the injection of sodium iothalamate seemed however to cause a little stronger mean reaction when given into the common carotid artery No explanation of this has been found The result may have been due to chance The differences were not significant, however The tachycardial reactions were all more marked after injection into the internal *than into the common carotid artery but this difference was not significant*

The contrast media that were more active as regards cardiovascular reactions *had some tendency to cause more discomfort to the patients* The mean rank figures were for methylglucamine iothalamate Urografin and sodium iothalamate 1 87, 1 92, and 2 22, respectively These differences were however not statistically significant, nor was the slight increase in discomfort with later injections in one and the same patient The mean rank figures were for the 1st 2nd and 3rd injections 1 87 2 03, and 2 10, respectively With the exception of a few instances of periarterial hematoma no complications were observed

The bradycardial reaction (Fig 2) was stronger (= 56) after hypertonic (4 65 %) saline than after sodium diatrizoate 50 % (= 34) in the sole patient in whom hypertonic saline was injected A weaker *bradycardial reaction occurred* after saline 3 5 % No bradycardia at all occurred after injection of methyl glucamine diatrizoate *or after Urografin*

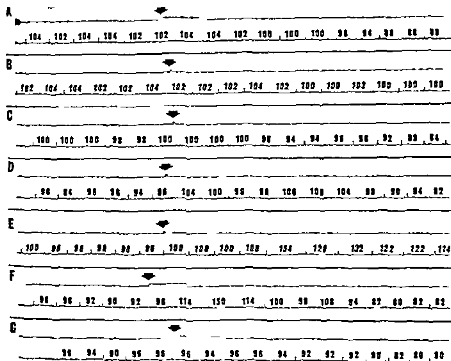


Fig 2 *Effects* of hypertonic saline on the heart rhythm Arrows indicate start of injections figures give the length of each heart cycle in 1/100 second Intracarotid injections of 5 ml of each one of the following contrast media were made in one and the same patient

Methylglucamine diatrizoate 60 % (A)

NaCl 0 9 % (B) 2 3 % (C) 3 5 % (D) and 4 65 % (E)

Sodium diatrizoate 50 % (Hypaque) (F)

Sodium methylglucamine diatrizoate 60 % (Urografin) (G)

There was a marked bradycardial reaction after injection of NaCl 4 65 % and Hypaque 50 % but no bradycardial reaction after the methylglucamine compounds

Discussion

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The bradycardial reaction during carotid angiography was first observed with other now rarely used contrast media namely iodopyracet and sodium acetri

zoate The reaction after injection of these media was greater, particularly as regards the latter, than after a diatrizoate compound (SJOGREN 1957, LINDGREN 1959, EPSTEIN et coll 1959, FISCHER et coll 1961) As both acetrizoate and diatrizoate were tested in the form of sodium salts, the difference must have been due to the anion The contrast media now used, with the anions of diatrizoate, metrizoate and iothalamate, all have a low toxicity, the difference between them in this respect being little, if any They also produce small vascular effects, of about the same magnitude, when injected into the peripheral arteries as well as into the carotid arteries

For clinical reasons, however, it is not sufficient to have a contrast medium that is fairly good, there are always reasons for finding the best This makes it necessary to determine even smaller differencies between the various preparations and to study the different types of salts of suitable iodine containing acids

As mentioned in the introduction, FISCHER et coll (1962), during carotid angiography in human subjects, had results which were more favourable for methylglucamine salts of diatrizoate than for the sodium salts FISCHER et coll (1965), FUJII et coll (1963), GOTTLOB (1965) obtained the same results with iothalamate with different experimental methods in animals The present investigation shows that with iothalamate in human subjects there is a difference in favour of the methylglucamine salts in contrast media for carotid angiography, and that this difference is statiscally significant

The mechanism behind the bradycardial reaction during carotid angiography has been discussed in previous papers GREITZ (1956) reported it unlikely that it was elicited via the sinus carotis and suggested as an explanation a direct action by the contrast medium on vasomotor centres in the brain This was confirmed by LINDGREN et coll (1958), but EPSTEIN et coll (1959), after local infiltration anesthesia of the sinus carotis region in five patients, demonstrated how carotid injections failed to elicit the previous vagal responses HILAL (1966) made experiments in dogs and assumed that the bradycardia and its result, the first hypotensive phase after intracarotid injections of contrast media were elicited via receptors in the extracerebral vessel e g the lingual artery However both the present and the previous investigation have shown that in man a stronger or at least as strong, bradycardial reaction is usually elicited after injection into the internal carotid as after injection into the common carotid artery These findings thus agree more with the theory that the reaction is elicited via the brain

BROMAN & OLSSON, as early as 1949 investigated the effect of contrast media and other hypertonic solutions on the blood brain barrier They found that cerebral lesions after carotid injection of iodopyracet could not be attributed solely to an osmotic action, since these lesions were more marked than those

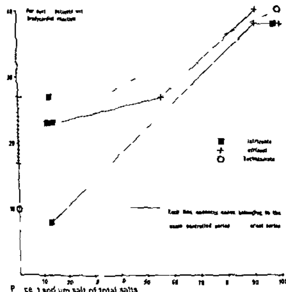


Fig 3 Collation of results from three previous series and the present investigation all performed with the same technique The material consists of 462 injections in 138 patients All the media had about the same concentration of iodine 280 to 299 mg/ml but those with a proportion of sodium salt greater than 90 % showed a tendency to cause bradycardial reactions significantly more frequently (in 38 to 40 % of the patients) than those with lower sodium salt concentrations

after hypertonic NaCl COTRIM (1954) and ŽSEBOK et coll (1954) on the other hand considered that solutions of NaCl isosmotic with the medium produced similar effects after intravenous injection as did iodopyracet and Uroselectan B on the respiration blood pressure and ECG Their opinion was however not in agreement with what was published later by e g GOTTLOB (1965) MARGOLIS et coll (1959) and READ (1959) observed an intravascular aggregation of red blood cells after injections of contrast media READ thought this effect could be explained by the hypertonicity of the medium

It has therefore again been discussed whether such reactions as occur with contrast media including the bradycardial reaction are also caused by other types of hypertonic solutions FRIESINGER et coll (1965) explained most of the hemodynamic consequences of left heart injection of a diatrizoate substance as being due to the hypertonicity of the solution The same opinion was expressed concerning metrizoate (BUSTFIELD et coll 1962) and iothalamate compounds (KLOSTER et coll 1966) HILAL (1966) injected sodium chloride in concentrations of from 2 5 % to 5 5 % and ZSEBOK et coll (1966) in a concentration of 8 1 % into the carotid artery of dogs and both regarded the cardiovascular reaction to be of a degree corresponding to that caused by contrast media

In order to form an idea of bradycardial reactions in human subjects after injection of hypertonic saline such solutions and contrast media were injected manually into the carotid artery of one and the same patient through one and the

same needle (Fig 2) Sodium chloride 4 65 %, which has the same concentration of sodium ions as sodium diatrizoate 50 % (or sodium iothalamate 50 %), caused in this patient stronger bradycardial reaction than Hypaque 50 %, saline 3 5 % produced slight bradycardia The discomfort of this patient was greater after saline 4 65 % than after any other media The planned series of injections of hypertonic saline in a large number of patients was therefore discontinued It seems necessary to perform such a comparison between saline and contrast media in a series of animals This single result is in agreement with the impression that the sodium salts of modern contrast media do not produce greater vascular effects than a sodium chloride solution of the same tonicity

The *ameliorating effect of calcium and magnesium ions* on the toxicity of sodium metrizoate in the isolated rabbit s heart, as shown by SALVESEN et coll 1964, must also be considered However, calcium and magnesium ions seem to play a lesser role *in diminishing the bradycardial reactions after carotid angio*graphy than does a large proportion of a methylglucamine salt (GREITZ et coll 1964, 1966) A high sodium concentration appeared to be the main cause of bradycardial reactions that occurred in connection with carotid angiography in the present investigation A graphic representation of the correlation established between the concentration of sodium in contrast media and the frequency of bradycardia is given in Fig 3, it includes all the results from the two previous investigations on diatrizoate and metrizoate compounds (GREITZ & TORNELL 1964, GREITZ, TELENIUS & TORNELL 1966) and those of the present investigation The material thus consists of 138 patients and 462 injections As may be seen from the diagram, the frequency of bradycardia is as high as between 38 and 40 % for anyone of the three modern contrast media used in the form of a pure or almost pure (92 to 100 %) sodium solution When methylglucamine solutions were injected, the frequency of bradycardia was subject to larger variations (8 to 27 %) but the tendency appears to be similar for the three media investigated

Severe bradycardia fortunately seems to be rare with modern media but may become rather marked, especially in patients with a slow cerebral circulation, as has been shown by GREITZ et coll (1964)

One serious complication which according to experimental and clinical reports may have a connection with the proportion between the sodium and methyl glucamine salts is ventricular fibrillation which has been observed at angiocardio graphy It seems to be elicited more readily by contrast media consisting mainly of high concentrated sodium salts (GENSINI et coll 1964 PORSTMANN 1963) Reports on clinical complications with ventricular fibrillation occurring when such types of contrast media were injected have been published by BERNSTEIN et coll (1962), LODA et coll (1965), and MELNICK (1966) ZIMMERMAN et coll

(1966) and AMPLATZ (1966) have expressed the opinion that the media used may have been the plausible cause If so it seems reasonable to prefer media consisting of methylglucamine compounds or a mixture with only a small proportion of sodium salts for rapid injection in large amounts into the heart or great vessels as well as for injection in lower concentrations and smaller amounts during cerebral angiography

Acknowledgement

The present investigation has been financially supported by AB Astra Sodertalje Sweden which is gratefully acknowledged

SUMMARY

ECG recording of bradycardia following intracarotid injections of contrast media has been found to constitute a sensitive method of comparison between such media The bradycardial reaction induced by sodium methyl lucamine diatrizoate (Urografin) and methylglucamine iothalamate (Conray) was significantly less marked than that produced by sodium iothalamate (diluted Angio-Conray) The methylglucamine compounds therefore appear to be preferable for cerebral angiography The bradycardial reactions caused by contrast media and other hypertonic solutions are discussed

ZUSAMMENFASSUNG

Nach Injektion von Kontrastmitteln in die Carotis Arterien wurde die auftretende Bradykardie elektrokardiographisch registriert Dies Verfahren erbietet eine empfindliche Methode um einen Vergleich zwischen Kontrastmitteln anzustellen Die Bradykardie nach Natrium Methylglucamin Diatrizoat (Urografin) und nach Methylglucamin Iothalamat (Conray) war bedeutend schwacher als nach Natrium Iothalamat (schwache Losung von Angio-Conray) Demgemass wird vorgeschlagen dass Methylglucamin Praparate fur cerebrale Angiographien vorzuziehen sind Die von Kontrastmitteln und anderen hypertonischen Losungen verursachten Bradykardie Reaktionen werden diskutiert

RÉSUMÉ

L auteur décrit l enregistrement électrocardiographique de la bradycardie qui suit l injection intracarotidienne de moyens de contraste qui est une méthode sensible de les comparer La réaction bradycardique due au diatrizoate de sodium méthylglucamine (Urografin) et a l iothalamate de méthylglucamine (Conray) a été notablement moins marquée que celle produite par l iothalamate de sodium (Angio-Conray dilué) Les sels de méthylglucamine paraissent donc préférables pour l angiographie cérébrale Les réactions bradycardiques causées par les moyens de contraste et par d autres solutions hypertoniques sont discutées

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FROM THE VETERANS ADMINISTRATION HOSPITAL, ALBANY, AND THE STERLING WINTHROP RESEARCH INSTITUTE, RENSSELAER, NEW YORK, U S A

EXCRETION OF METRIZOATE IN MAN

by

JOHN B DAWSON, EVAN W MCCHESNEY and FRANKLIN F TELLER

Isopaque 300 is a solution of metrizoic acid (3 acetamido 2,4 6 triiodo 5[N methylacetamido] benzoic acid) in a balanced mixture of sodium, calcium, *magnesium and N methylglucamine salts (Isopaque is a registered* trade name of Winthrop Laboratories, New York U S A Metrizoic acid was first prepared in the laboratories of Nyegaard and Company, Oslo, Norway) *The concentrations of these salts in the order named are* 43 1 5, 0 5, and 7 9 % This composition provides an organic iodine content of 300 mg/ml, with a specific gravity of 1 31 (Winthrop Laboratories 1966) Metrizoic acid has been extensively *studied as the sodium salt, in* both laboratory and clinic Its toxicity for the mouse has been found by BUSFIELD et coll (1962) to be about equal to that of diatrizoate but other studies in the Winthrop Laboratories have shown the animal toxicity of the Isopaque 300 formulation (based on equivalent amounts of iodine administered) to be about 70 % of that of sodium diatrizoate Although studies in man (PATTINSON 1962, AMUNDSEN 1965) have indicated little difference in tolerance between diatrizoate and metrizoate, when these compounds were administered as the sodium salts or as *mixtures of sodium and N methylglucamine salts* PATTINSON felt there were some overall advantages in favor of metrizoate In a com

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Preliminary animal experiments on the excretion of iodine following the administration of sodium metrizoate (Winthrop Laboratories 1966) have shown that

1 Six hours after an intravenous dose of 100 mg/kg to rabbits the mean recovery from the urine was 88 4 % and from the bile it was 2 2 % Periodic blood analyses indicated a half life of 55 min

2 Six hours after an intravenous dose of 100 mg/kg to cats the mean recovery from the urine was 86 6 % and from the bile it was 4 8 % Periodic blood analyses indicated a half life of 85 min

3 Male rabbits receiving 1000 mg/kg doses intravenously excreted half of the dose in approximately 50 min and 75 % of the dose in 100 min

The purpose of the present experiments has been to study the excretion of metrizoate in man with the expectation of being able to demonstrate that it is eliminated at a rate entirely comparable to that already observed in the two animal species

Experimental protocol Following physical examination and recording of the subject s medical history (especially with the objective of establishing the renal status recent ingestion of halogen containing drugs present and recent medical therapies smoking and coffee drinking habits) the experimental procedures were described to the subject in detail in order to obtain the maximum degree of patient cooperation The subject was asked to discontinue the use of coffee and tobacco for the next 2 to 3 days On the day prior to the actual test a 24 hour urine collection was started at 7 a m to be examined for volume osmolality and content of urea N creatinine, sodium potassium magnesium chloride and total protein At 2 p m the subject received his first bowel preparation (30 ml of milk of magnesia 500 ml of water 1 tablet each of senna and bisacodyl and four 40 mg tablets of simethicone) On the following day at 6 a m the subject received the second part of the bowel preparation (500 ml of water and one suppository each of senna and bisacodyl)

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At 8.30 a.m., in the ward, the subject's vital signs were recorded, and a clean specimen of urine was obtained for routine analysis. A sample of blood was also obtained, from the left arm, for determinations of osmolality, urea N, creatinine, sodium, potassium, magnesium, chloride, bicarbonate, glucose, hemoglobin, hematocrit, white cell and differential counts. Following these preliminary steps, the following steps were performed;

1. A test dose of Isopaque 300 (1 ml) was injected into the left arm.
2. A 325 mg capsule of carmine stool marker was given orally with water.
3. A scout film was obtained and examined.
4. Thirty ml of Isopaque 300 were injected into the left arm (time 'zero').
5. Roentgenograms were obtained at 2, 5, 10, 15 and 30 min, and the power settings were noted.
6. Pulse, temperature and blood pressure were determined at 15, 30 and 360 min.
7. EDTA treated venous blood samples were obtained at 0, 30, 120, 240 and 360 min. In some cases 10 and 20 min samples were also obtained.
8. Urine samples were collected quantitatively under toluene for the periods 0—2, 2—6, 6—12 and 12—24 hours (in one case, also for 24—48 hours). These samples were stored at 4° C until they could be analyzed, but the interval between collection and analysis did not exceed 4 days in any case.
9. Stools were collected until the carmine marker came through.

A total of 7 male subjects participated in these studies. They ranged in age from 20 to 50 years, and in weight from 66 to 96 kg. All were well within normal limits with respect to the numerous parameters of blood and urine chemistry listed above. In the urine occasional RBC, leucocytes, and epithelial cells were noted, as well as some debris in the form of amorphous phosphates, mucus, and oxalates. That all subjects but one had normal renal function was demonstrated by the fact that their creatinine clearances fell in the range of 84—150 ml/min. In the one exceptional case the low clearance value observed was believed attributable to an incomplete urine collection.

Methods of analysis. The blood plasma was separated promptly and aliquots were analyzed for total iodine by the method of ZAK & BOYLE (1952). The amounts found in the zero hour samples (usually negligible) were subtracted from the values found on all subsequent samples from that subject, to give the *net* values. Urine and fecal samples, the latter prepared for analysis as weighed aliquots of uniform suspensions, were analyzed by the same method. To determine the chemical nature of the excretory product, a urine sample

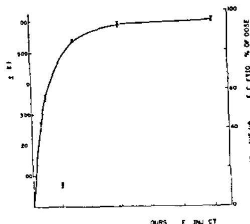


Fig 1 Plasma levels and cumulative urinary excretion (as mean ± S E) of iodine in seven subjects following the intravenous administration of a standard dose (31 ml) of Isopaque 300 The broken line represents an extrapolation of the plasma level curve on the basis that in the 6—12 hour post medication interval the log conc of plasma iodine would be a linear function of time Fecal excretion = 1 6 ± 0 3 of dose

from one subject (for the 0—2 hour interval) was acidified with sulfuric acid Since no precipitation occurred the sample was thoroughly extracted with ether which was evaporated to dryness The crystalline residue was examined by Mr A V R Crain by chromatography on a thin layer of silica gel using the solvent system (by volume) formic acid 10 methanol 10, ether 25 chloroform 55 in this system the Rf of metrizoic acid is 0 4 Urine samples were also tested for the presence of iodide by means of the familiar nitrous acid starch reaction

Results and Discussion

The mean plasma iodine levels for the seven subjects are presented in Fig 1 plotted against time and extrapolated beyond 6 hours postmedication on the basis that during the 6—12 hour interval the term [log conc] should be linearly related to time The mean cumulative urinary excretion as percentage of dose is plotted on the same graph and for both variables the standard errors of the means are shown as vertical bars

It is quite apparent from the figure that the two parameters which have been plotted are functionally related i e the plasma iodine level decreases at the same rate as the radiopaque is excreted in the urine However when log [plasma iodine concentration] is plotted against time (see Fig 2 as an example) it becomes apparent that more than one rate process is involved in determining the nature of the plasma iodine regression curve To establish the exact nature of this curve required data on some intervals earlier than 30 min postmedication Such data are presented for one subject in Fig 2 in

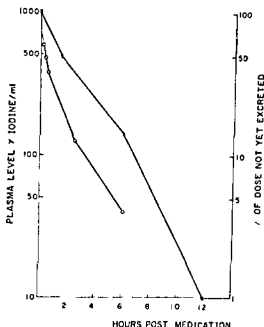


Fig 2 Plasma iodine levels (circles) and percentage of dose not yet excreted (crosses) in the urine for one subject (W T) plotted on a semilog basis

which (a) log plasma iodine concentration, and (b) percentage of dose not yet excreted in the urine, are plotted against time after medication This figure suggests that there might be as many as three distinct phases in the plasma iodine regression curve The first would have a half life of 32 min, while the third would have a half life of 125 min, and the second (0 5 to 2 5 hours) could be regarded as transitional A more rigorous pharmacokinetic analysis of these plasma level data has shown that there were, however, only two rate processes involved, and that they had half lives of 14 and 127 min A similar analysis showed half lives of 18 and 132 min for subject J V, and of 15 and 100 min, respectively, for the seven subjects considered as a group The elimination rate for subject W T for the 1 5—12 hour period may be seen to parallel quite closely the longer of the two plasma half lives (Fig 2)

Elimination rates involving at least two half lives seem to be characteristic of the urographic agents, BLAUFOX et coll (1963), for example, from a study of the plasma regression rates of diatrizoate in dogs, concluded that a 2 compartment system was involved Similarly, STOKES & TER PERGOSSIAN (1964), in a study of the excretion of diatrizoate in man, concluded that the plasma iodine regression curve resulted from rate processes having half lives of 52 and 120 min However, similar experiments on the excretion of diatrizoate in 15 normal male subjects led CATTELL et coll (1967) to conclude that there were three distinct phases in the handling of this compound The first

of these involved dilution of the contrast agent to a volume of 2 4 l the second involved its mixing in the extracellular fluid (volume 12 l), and the third involved excretion with of course all three processes going on simultaneously An examination of the plasma level curves presented by CATTELL et coll (which covered the 1—30 min interval only) reveals that there were actually two rate processes involved in the 1—30 min interval the first having a half life of 4 min and the second a half life of 72 min Further analysis reveals that the 72 min half life represents a combination of the 52 and 120 min half lives observed by STOKES & TER PERGOSSIAN Metrizoate therefore would appear to differ from diatrizoate only in that the first of its 2 rate processes has a considerably shorter half life It is this process which is governed by the rate of distribution of the agent in the available water space

The total human renal excretion of $86 \pm 0\ 7$ % of metrizoate in 6 hours is almost exactly the same as has been observed for the cat (86 6 %) and for the rabbit (88 4 %) for the same time interval In the present experiments a urine collection was made for the 24—48 hour period in only one subject It contained 10 mg of iodine or approximately 0 1 % of the dose The mean fecal output which was 147 ± 28 mg or $1\ 6 \pm 0\ 3$ % of the dose added to the 24 hour urinary excretion of 95 3 % brings the total 24 hour recovery up to a mean of 96 9 % of the amount administered and indicates a ratio of urinary to fecal excretion of about 60/1 As was expected for a substance which is so rapidly eliminated the urinary excretory product proved to be unchanged metrizoic acid in the one sample so studied and of the many urine samples examined by the nitrous acid starch reaction, none was found to contain iodide

Acknowledgements

The authors are indebted to Mr W F Banks Jr for his technical assistance and to Dr G A Portmann for his kinetic analysis of the plasma level data

SUMMARY

The excretion of metrizoate following the administration of a balanced solution of the sodium calcium magnesium and N methylglucamine salts has been studied in seven physically normal subjects The compound was rapidly eliminated in the urine (86 % in 6 hours) in unchanged form the 24 hour excretion exceeded 95 % of the dose The fecal excretion averaged 1 6 % of the dose indicating a ratio of urinary to fecal excretion of about 60/1 The observed plasma iodine levels suggested that their regression rate was determined by two rate processes having half lives of about 15 and 105 minutes

ZUSAMMENFASSUNG

Die Ausscheidung von Metrizoat nach Verabreichung einer balanzierten Losung von Natrium Kalzium Magnesium und N Methylglukamin Salze wurde in sieben gesunden Individuen studiert Die Substanz wurde schnell im Urin unverandert ausgeschieden (86 % in 6 Stunden) Die 24 Stunden Ausscheidung war mehr als 95 % der Dosis Die fakale Exkretion war durchschnittlich 1 6 % der Dosis was auf eine Urinexkretion im Verhaltnis zur fakalen Exkretion in der Rate von etwa 60/1 deutet Aus den beobachteten Plasma Jod Gehalten geht hervor dass die Regressionsverhaltnisse von zwei Rate Prozessen mit Halbwertzeiten von etwa 15 und 105 Minuten abhangen

RÉSUMÉ

Les auteurs ont étudié l excrétion du métrizoate après administration d une solution équilibrée de sels de sodium de calcium de magnésium et de N méthyl glucamine a sept sujets en bonne santé physique Le produit sans changer a été rapidement éliminé dans l urine (86 % en 6 heures) l excrétion de 24 heures était superieure a 95 % L excrétion fécale était environ 1 6 % de la dose ce qui correspond à un rapport de l excrétion urinaire à l excrétion fécale d environ 60/1 Les taux d iode plasmatique observés font penser que leur vitesse de régression dépend de deux processus ayant des demi vies d environ 15 et 105 minutes

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FROM THE ROENTGEN DEPARTMENT OF THE NEUROLOGIC CLINIC (DIRECTOR PROF K HENNER), CHARLES UNIVERSITY PRAHA CZECHOSLOVAKIA

POSITION OF THE LUMBAR INTUMESCENCE OF THE SPINAL CORD

by

JAN JIROUT

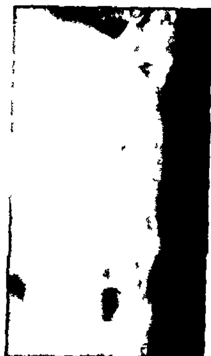
In our earlier pneumographic studies of the mobility of the spinal cord in normal individuals (JIROUT 1963) it was observed that the anterior arachnoid space in lateral views often appeared narrowed at the level of the lumbar intumescence This is partly due to the bulging of the ventral contour of the lumbar intumescence and partly to a true ventral displacement and ventral *curving of* the caudal end of the spinal cord This shape is considered to be a remnant of the curvature of the embryonic spinal cord (ROTH 1965 1966) The lumbar enlargement may sometimes be so close to the ventral wall of the spinal canal that the ventral arachnoid space is obliterated

The question arises as to whether the lumbar intumescence is actually fixed in this ventral position to such a degree as to be damaged by the pressure of various pathologic structures (disks bony spurs) protruding from the ventral wall of the *spinal canal*

In measurements of the extent of the ventrodorsal mobility we found the mobility of the caudal end of the spinal cord to be considerably *greater* 3 2 mm on an average than the mobility of other parts of the thoracic spinal cord (1 5 to 2 mm on an average) This fact seemed *to indicate* that the ventral position or ventral curving of the caudal end of the spinal cord is inconstant

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With a view to gather reliable information about space relations between the lumbar enlargement and the anterior wall of the spinal canal and whether these were constant we have procured lateral pneumograms in supine position Fifty two subjects, most of them with lumbar diskopathy but with normal conditions in the thoracolumbar region, were examined In all of them excepting one, the site of the lumbar enlargement was *close to the posterior* wall of the spinal canal The anterior arachnoid space was well filled and its width, as measured on the *films, ranged from 2 mm to 11 mm* (average 5 5 mm) (see accompanying illustration)



In the supine position the lumbar intumescence lies close to the posterior wall of the spinal canal and the anterior arachnoid space is widened

The lumbar roots run in a ventrocaudal direction and it may therefore be assumed that they fix the caudal end of the cord to the ventral wall of the spinal canal, especially when the nerve roots are under tension Additional lateral films were therefore obtained in eight subjects, in the supine position with maximal flexion of the hip joints and extension of the knees The dorsal position of the caudal end of the cord remained unchanged in seven of these but in one subject it moved to the ventral wall of the canal

The fact that all but one of the fifty two subjects examined supine had a sufficiently wide anterior arachnoid space at the level of the lumbar intumescence seems to indicate that there is usually ample space for the cord to recede backwards provided there is no marked congenital narrowing of the spinal canal The influence of the spinal nerve roots on the ventrodorsal mobility of the caudal end of the cord would also appear to be insignificant Stretching of the lumbar nerve roots may however in some subjects result in ventral displacement of the caudal end of the cord

It thus seems improbable that subjects in whom the width of the spinal canal is normal would be likely to incur myelopathy as a result of a ventrally situated lumbar intumescence This view is supported by clinical evidence Myelopathies resulting from spinal cord compression by pathologic structures protruding from the anterior wall of the spinal canal are relatively rare in the thoracolumbar region and far less frequent there than in other parts of the spine

The conclusion may therefore be drawn that at the level of the lumbar in

tumescence there is a greater possibility than in any other parts of the thoracic spinal canal for the spinal cord to move dorsally and avoid pressure from its ventral aspect

Addendum in proofs

Since July 1967 the number of subjects examined have increased In 69 out of 70 cases the lumbar intumescence was found to be adjacent to the posterior wall of the spinal canal in supine position In 17 of 18 cases the position of the caudal end of the cord remained unchanged in supine position with maximal flexion of the hip joints and extension of the knees

SUMMARY

The lumbar intumescence of the spinal cord was found to lie close to the posterior wall of the spinal canal in 51 out of 52 normal subjects examined supine by pneumography This would appear to be an indication that at this level the cord is able to avoid pressure effects from its ventral aspect

ZUSAMMENFASSUNG

Es wurde bei einer Untersuchung von 52 normalen Fallen mittels Pneumographie in Ruckenlage festgestellt dass in 51 von diesen Fallen die lumbale Intumeszenz des Ruckenmarks ganz nahe der hinteren Wand des Ruckenmarkskanales lag Dies scheint darauf hin zu deuten dass das Ruckenmark in dieser Gegend die Fahigkeit besitzt ventrale Druckeffekte zu vermeiden

RÉSUMÉ

Chez 51 sur 52 sujets normaux examines par pneumographie en decubitus le *renflement lombaire* de la moelle epiniere etait situe pres de la paroi posterieure du canal *rachidien*. Ceci semble indiquer que la moelle a ce niveau est capable d'eviter des compressions venant de la face anterieure du canal rachidien

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FROM THE DEPARTMENT OF DIAGNOSTIC RADIOLOGY (DIRECTOR PROF F KNUTSSON), THE UNIVERSITY HOSPITAL, UPSALA, SWEDEN

NORMAL TOPOGRAPHY OF THE CEREBRAL VENTRICULAR SYSTEM IN CHILDHOOD

by

HERMAN LODIN

The anatomical relationships between the ventricular system and the cranial cavity in children have received some attention The relatively high position of the third ventricle above the sella turcica and its progressive downward displacement during the first ten years of life have been described and similarly the relatively high position of the fourth ventricle above the foramen magnum has also been recorded (ROBERTSON)

The aim of the present investigation has been to study the relations during the period of growth between certain anatomical structures within the ventricular system and landmarks on the base of and within the skull

Material All unequivocally pathologic cases (intracranial expansion hydrocephalus dilatation of one lateral ventricle, and malformations) were first excluded from the total material of encephalographies in children under 15 years of age Cases with a large amount of subdural air were also not considered suitable This left 164 negative encephalographies as a basis for the study The material included a few cases with relatively wide convexity grooves and rather wide lateral ven

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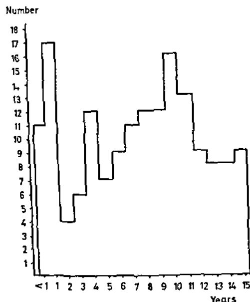


Fig 1 Age distribution in the material

tricles the widths of the anterior horns were however less than one third of half the inner cranial diameter (cf LINDGREN) The age distribution is shown in Fig 1 Twenty-eight of the patients were aged from 0 to 2 years 38 were 0 to 4 and the remainder between 5 and 15 years

All encephalographies were performed by the fractionation method following lumbar puncture in all other respects the investigations were performed under similar conditions on a Lysholm skull table The enlargement factor in the series varied with the width of the skull and no correction for these variations was made

Measurement technique All measurements were made from films obtained in the lateral projection The reference points and lines used in the measurements are given in Fig 2 In the case of the third ventricle the measurements were made on lateral films obtained with the patient in the recumbent position Distances in relation to the aqueduct and the fourth ventricle on the other hand were measured on lateral films obtained sitting (standard films and autotomograms) In about 20 cases different parts of the ventricular system were compared in these two projections and no measurable changes in the relationships of position were noted As regards the third ventricle this is in agreement with the observations of BULL

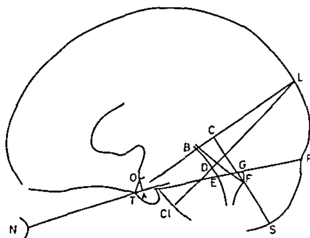


Fig 2 Landmarks and reference lines Cl—clivus F—Fastigium L—lambda N—nasion O—optic recess of third ventricle P—protuberantia occipitalis interna S—squama ossis occipitalis T—tuberculum sellae

A—point where the normal from optic recess (O) meets the extended nasion–tuberculum line (N—T)

B—point where the tuberculum—lambda line (T—L) intersects floor of aqueduct

C—point where the normal from fastigium (F) meets the tuberculum—lambda line (T—L)

D—point where the clivus—lambda line (Cl—L) intersects floor of aqueduct

E—point where the tuberculum—protuberantia line (T—P) intersects floor of fourth ventricle

G—*point where the normal from* fastigium (F) meets the tuberculum—protuberantia line (T—P)

Certain anatomical relationships were determined by distance measurements and others by calculation of the ratios between distances The mean values for the distances or the ratios obtained were calculated for each year group and were then plotted on a coordinate system, after which a curve line was interpolated between the different values

Results

Optic recess of the third ventricle BULL'S chiasmal point (0) was used as reference point for the optic recess This has been defined by BULL as the deepest insertion of the wall of the third ventricle between the optic and infundibular recesses The position of the chiasmal point was determined inter alia in relation to the tuberculum sellae (T) This point is clearly defined and easy to find in the roentgen film but because of the variations in length and orientation of the dorsum sellae it was avoided as a reference point A line projected through the nasion (N) and the tuberculum sellae was used as a reference line (N— T) The distances measured were (Fig 3)

1 O—T, the distance between the chiasmal point and the tuberculum sellae

2 O—A, the perpendicular distance from the chiasmal point to the projected N—T line,

3 T—A, the distance from the tuberculum sellae along the projected N—T line to the normal O—A

mm

O T ( )

O A (x)

T A

Years

O T A N

Fig 3 Relationship of the optic recess (O) N—T—nasion—tuberculum line A—point where the normal from O meets this line

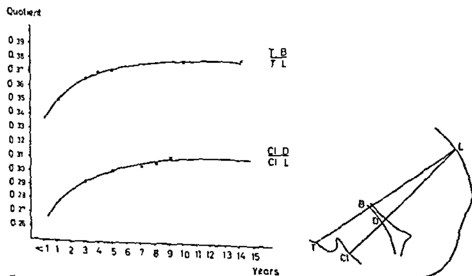


Fig 4 Relationships of the aqueduct B—point where the tuberculum—lambda line (T—L) intersects the floor of the aqueduct D—point where the clivus—lambda line (Cl—L) intersect the floor of the aqueduct

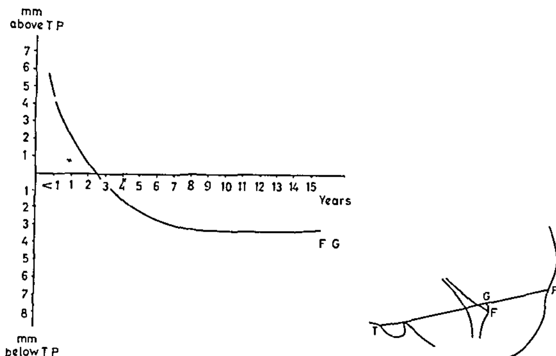


Fig 5 Relationship of the fourth ventricle G—point where the normal from fastigium (F) *meets the tuberculum—protuberantia line (T—P)*

By measuring these three distances an idea was obtained of the distance from the chiasmal point to the tuberculum sellae (T) *as well as of the position of the* former, both vertically above the nasion tuberculum sellae line (N—T) and in a fronto-occipital direction along this line

The results of the measurements are given in Fig 3 Distance O—T decreases somewhat with increasing age, as does distance O—A, the latter decrease is *somewhat more marked, however Thus with increasing age the chiasmal point* approaches the nasion tuberculum sellae line and the base of the skull A more marked change occurs for distance T—A with increasing age The chiasmal point is thus more displaced in a fronto occipital direction than towards the base of the skull The greatest displacement in a fronto-occipital direction takes place during *the first two years of life, whereas the basal movement occurs somewhat more* slowly The principal change in positions is completed at an age between 6 and 7 years

Aqueduct Both the line between the tuberculum sellae and the lambdoidal suture (T—L), and the normal from the dorsal side of the clivus to the lambdoidal suture (Cl—L) were used as measurement lines for determining the

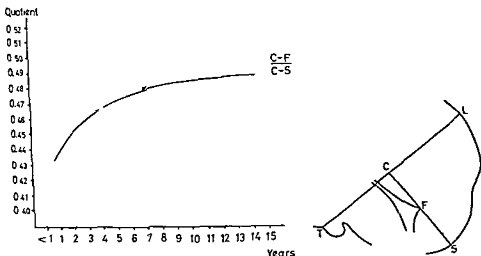


Fig 6 Relationship of the fourth ventricle C—point where the normal from fastigium (F) meets the tuberculum—lambda line (T—L)

position of the aqueduct in relation to the base and dome of the skull (Fig 4) The position of the aqueduct has been given both as a ratio between the distance from the tuberculum sellae to the ventral wall of the aqueduct (T—B) and the distance from the tuberculum sellae to the lambdoidal suture (T—L) as well as as a ratio between the distance from the clivus to the ventral wall of the aqueduct (Cl—D) and the distance from the clivus to the lambdoidal suture (Cl—L) The anterior of these lines generally crossed the most anterior part of the aqueduct while the posterior line traversed its posterior part The results of the measurements are given in Fig 4 The two curves follow the same course The aqueduct recedes somewhat from the clivus and after the age of about 5 years maintains a relatively unchanged position in relation to the base and dome of the skull

Fourth ventricle The level of the fourth ventricle (Fig 5) was determined in relation to the tuberculum sellae—internal occipital protuberance line (T—P) The fastigium (F) was used as reference point in the fourth ventricle this point being easily identified in the roentgen film (automogram) The position of the fastigium was determined in relation to T—P by measuring the perpendicular distance to T—P from F (F—G) When the fastigium was situated above the line the measured distance was regarded as positive and when it was situated below the line it was considered negative The distance F—G is indicated in

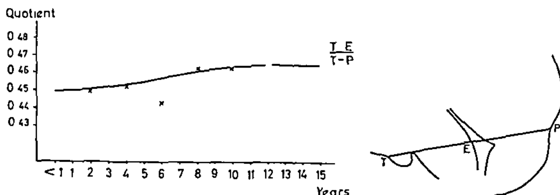


Fig 7 Relationship of the fourth ventricle E—point where the tuberculum—protuberantia line (T—P) intersects the floor of the fourth ventricle

Fig 5 The fastigium moves with increasing age from a position above T—P to one below T—P From 6 to 7 years of age and onwards, the fastigium occupies a more constant position in relation to the above mentioned reference points in the vault of the skull (T—P)

To shed further light on the position of the fastigium, a reference line was drawn perpendicularly through the fastigium from the tuberculum sellae—lamb doidal suture line (T—L) (Fig 6) The distance from this line to the fastigium (C—F) was compared to the distance C—S, i e that point in the occipital squama that is met by the normal through F from the line T—L When the position of the fastigium was given as the ratio between distances C—F and C—S, the result shown in Fig 6 was obtained This figure, like Fig 5 indicates how the fastigium of the fourth ventricle moves in the direction of the occipital squama to occupy a more constant position by the age of 6 to 7 years

The position of the fourth ventricle in relation to the clivus (Fig 7) was *determined by using the reference line from the tuberculum sellae to the internal* occipital protuberance (T—P) Its position has been given as the ratio between the distance T—E where E marks the point of intersection with the base of the fourth ventricle, and the distance T—P As may be seen from Fig 7, a relatively minor, gradual displacement occipitally of the fourth ventricle in relation to the clivus and essentially completed by the age of 6 to 8 years takes place

A relatively rapid change in position of the fourth ventricle in the direction of the occipital squama thus occurs during the first 6 to 7 years of life Further more, *a less marked displacement away from the clivus is the rule during the* period

The anatomical relationships at the ages of 1, 5 and 10 years, are summarized in Fig 8

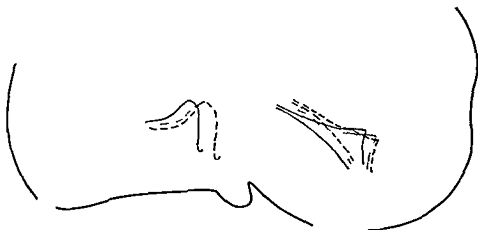


Fig 8 Anatomical relationships at the age of 1 year (——) 5 years ( ) and 10 years (— — —)

Discussion

The curves now presented are based on mean values for distances and quotients The separate measurements on which these are based vary considerably probably due mainly to natural variations in shape and development of the skull during the growth period The material comprises a group of about 10 cases per year which is insufficient for a statistical analysis It does however allow more precise knowledge to be gained about the normal conditions of physiologic development and with reservation for the relatively large individual variations the curves can be regarded as normal

The distance between the aqueduct and the dorsum sellae in adults is normally about one third of a line thought to pass from dorsum sellae through the aqueduct to the skull vault (SAHLSTEDT 1935) No exact comparison with this method has been possible in the actual measurements since the position of the aqueduct has been determined along the lines from the tuberculum sellae and the clivus to the lambdoidal suture The actual measurements will after the ages of 6 to 8 years give slightly higher quotients for the more frontal line and slightly lower quotients for the more occipital line in comparison with the above mentioned Swedish line

According to TWINING (1939) the centre of the fourth ventricle is located midway between the tuberculum sellae and the torcular In this paper the base of the fourth ventricle is used as a reference point and this gives slightly lower quotients than the Twining method

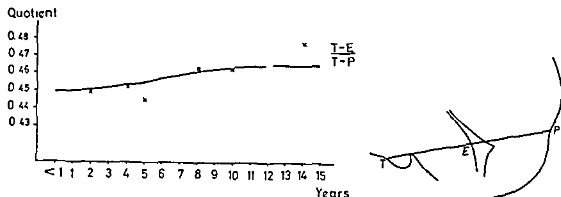


Fig 7 Relationship of the fourth ventricle E—point where the tuberculum—protuberantia line (T—P) intersects the floor of the fourth ventricle

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The position of the fourth ventricle in relation to the clivus (Fig 7) was determined by using the reference line from the tuberculum sellae to the internal *occipital protuberance* (T—P) *Its position has been given as the ratio between* the distance T—E, where E marks the point of intersection with the base of the fourth ventricle, and the distance T—P As may be seen from Fig 7 a relatively minor, gradual displacement occipitally of the fourth ventricle in relation to the clivus and essentially completed by the age of 6 to 8 years takes place

A relatively rapid change in position of the fourth ventricle in the direction of the occipital squama thus occurs during the first 6 to 7 years of life Furthermore, a less marked displacement away from the clivus is the rule during the period

The anatomical relationships at the ages of 1, 5 and 10 years, are summarized in Fig 8

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REGIONAL CEREBRAL BLOOD FLOW AND ANGIOGRAPHY IN APOPLEXY

by

STEN CRONQVIST

Cerebral lesions may be demonstrated roentgenographically not only as changes in anatomical structures but also as localized or generalized changes in the dynamic circulatory pattern Such changes in the cerebral blood flow have also been demonstrated by means of quantitative measurements of the cerebral blood flow EKBERG CRONQVIST & INGVAR 1965 CRONQVIST EKBERG & INGVAR 1965)

A series of cases of focal cerebrovascular lesions were investigated both by cerebral angiography and measurement of the regional cerebral blood flow (rCBF) New pathologic aspects on the focal cerebrovascular lesions were suggested by the combination of the two procedures and new roentgendiagnostic criteria in focal cerebral ischaemia were indicated Preliminary reports on the present material have recently been published (CRONQVIST 1966 CRONQVIST & LAROCHE 1967)

Methods The patients were all examined by angiography of the internal carotid artery Serial lateral films were obtained at 2 films per second during the

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The physiologic conditions explain the relatively great distances between the sellar region and the recesses of the third ventricle that appear in the youngest age groups. It may be concluded that the intracranial portion of the optic nerve reaches its final length at an early age. The more frontal position of the chiasma and the large suprasellar cisterns at this age may mean that suprasellar tumours in this region must be relatively large before they produce clinical signs.

SUMMARY

Physiologic changes in position of the optic recess of the third ventricle, the aqueduct and the fourth ventricle during the period of growth were studied in a material of just over 160 normal encephalographies. The changes take place during the first 6 to 8 years but are most *marked during the first two years of life.*

ZUSAMMENFASSUNG

An einem Material von uber 160 normalen Enzephalographien wurden die physiologischen *Veranderungen der Lage des Recessus opticus des dritten Ventrikels, des Aquaducts und des* vierten Ventrikels wahrend der Wachstumsperiode untersucht. Die Veranderungen entwickeln sich in den ersten 6 bis 8 Lebensjahren, vorzugsweise aber wahrend den ersten 2 Lebens*jahren.*

RÉSUMÉ

L'auteur a étudie sur un peu plus de 160 encephalographies normales les modifications physiologiques de la position du recessus optique du troisieme ventricule, de l'aqueduc et du quatrieme ventricule au cours de la croissance. Ces modifications ont lieu pendant les six à huit premieres années et sont plus marquees au cours des deux premieres annees de la vie.

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Table 2

	Angiographic findings	Number of cases	Interval onset of symptoms examination (days)	Range of variation (normal range 30)	Type of lesion
Cases with focal flow abnormality	Abnormal (early veins blush)	6	6 6 (1—17)	59 (36—57)	Focal hyperaemia
	Abnormal	9	14 3 (5—29)	38 9 (30—53)	Focal ischaemia
	Normal	2	93 0 (18—165)	47 5 (33—62)	Non focal
Cases without flow abnormality	Normal and abnormal	30	23 0 (4—91)	< 30	

calculated as a weighted average in ml/min/100 g brain tissue (HOEDT RASMUSSEN SVEINSDOTTIR & LASSEN 1966) The normal mean rCBF obtained with this method in healthy controls is 49 7 ± 5 6 ml/min/100 g The fast type of flow has a normal value of 79 7 ± S D 10 7 and the slow type of flow 20 9 + S D 2 6 ml/min 100 g (INGVAR et coll 1965) In the present analysis mainly the fast flow values (rCBFf) have been considered since it has been shown (INGVAR & RISBERG 1967 INGVAR & SULG) that these appear as more sensitive indicators of regional functional changes in the brain than other types of flow

Studies in normal subjects indicated certain differences in rCBF between different parts of the hemisphere (INGVAR CRONQVIST LKBERG et coll 1965) For the fast flow the difference between the maximal and the minimal regional flow i e the normal range of variation had a mean value of 19 4 per cent (± S D 4 64) of the hemisphere values Thus whenever the difference between the highest and the lowest rCBFf exceeded 30 per cent (m ± 2 S D) an abnormal variation indicating a focal abnormality of the cerebral blood flow was present

Material The series consists of 51 cases 30 men and 21 women Cases with clinical or roentgenologic signs of disturbance of the cerebral circulation due to cerebral haemorrhage emboli thrombosis or to arterial stenosis were included in the investigation Cases in which the symptoms were due to a subarachnoidal haemorrhage or caused by a cerebral tumour were excluded and will be dealt with separately (CRONQVIST & KAGSTROM CRONQVIST & AGEE 1968) At the time of the combined rCBF angiography examinations which took place 1 to 165 days following the acute onset of symptoms the majority of cases presented clinical signs referable to supratentorial structures Four cases with signs

Table 1

Material of 51 cases in group divisions according to the angiographic findings

Group	Angiographic findings	Number of cases	Flow values (compartmental analysis)			Focal abnorm
			Mean (49.7 ± 10.7)	Fast (79.7 ± 10.7)	Slow (20.9 ± 2.6)	
I	Angiography normal	15	40.7	65.1	19.4	2
II	*Angiography abnormal*	*32*	*33.4*	*56.1*	*16.5*	*15*
	a) Space occupying lesions	16	35.3	61.4	16.8	9
	b) Art. occlusions	9	35.9	60.1	17.8	5
	c) Art. stenoses	7	29.2	46.8	46.8	1
III	Cases with clinical signs of brain stem lesions	4	33.8	55.1	15.6	0

first 6 seconds, followed by 1 film per second for the next 4 seconds. Finally, tw additional films were obtained at 2 second intervals for 14 seconds.

The rCBF measurements, which always followed angiography, were made b the isotope clearance method introduced by INGVAR & LASSEN (1962) and adap ed for clinical use by LASSEN, HOEDT RASMUSSEN, SØRENSEN et coll. (1963 About 1 mCi of the radioactive freely diffusible gamma emitting inert gas, xeno 133, physically dissolved in 3 to 4 ml saline, was injected into the internal caroti artery. The injection was made through the same needle, or catheter, as was use for angiography. The uptake and subsequent disappearance (clearance) of the iso tope were recorded with four, or eight, extracranial scintillation detectors place lateral to the head at right angles to the sagittal plane (INGVAR, CRONQVIST, EK BERG et coll. 1965). The size of the detectors with a diameter of about 2.5 cm and the collimation used, permitted recording from a part of the labelled hem sphere forming a stumped cone, with lateral and medial diameters of about 4 cr and 5 cm, respectively. The activity of the isotope recorded by each detector wa followed for 15 minutes and was transferred to an ink writer via a tape recorder The ensuing curve, the clearance curve, the slope of which is determined by th blood flow within the field of the detector, may be considered as the sum of tw main mono exponential functions, representing a fast and a slow type of flow (HØEDT RASMUSSEN 1967). There is abundant evidence (KETY 1967, HØEDT RASMUSSEN 1967) that these two types correspond to the flow within the grey and white matter of the brain. From the two components, the mean rCBF can be

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Table 4

Repeat angiographic and rCBF studies in a case of cerebral infarct

	4 hours	3 days	8 days	21 days	41 days	120 days
Mean fast flow for all areas (ml/100g/min)	74 5	80 0	88 ?	77 4	83 9	47 3
Relationship flow in lesion area to non lesion areas ( )	79 0	119 0	157 0	—	95 0	74 0
Angiography	Avascular	Early vein			Normal	

Results

The average rCBF values for the different groups are given in Table 1 The fast flow was reduced in all groups The reduction was more obvious in cases with angiographic changes than in those without and amounted to 29 5 and 18.5 per cent respectively The decrease in flow was also related to the type of lesion cases with only a stenotic lesion or signs of stenosis presented the lowest fast flow values but those with clinically diagnosed lesions within the brain stem all had a marked decrease of rCBF of 31 per cent in the supratentorial structures as well

A non focal type of flow i e the difference between the maximal and the minimal rCBF did not exceed the range of normal variation was present in 34 cases i e the majority A focal abnormality of rCBFI according to the criteria given on page 523 was demonstrated in 17 cases (Tables 2 and 3) fifteen of these presented abnormal angiographic findings i e they belonged to group II High values within the region was the characteristic finding in six cases and in comparison with the flow in other regions a focal relative hyperaemia was present A focal low flow a focal relative ischaemia on the other hand was noted in nine cases Comparison of the results of the blood flow measurements and the angiographic findings indicated that the region or regions with the abnormal flow in all the 15 cases corresponded to the angiographic abnormality Three types of circulatory pattern could thus be observed in this series viz the non focal type the type with focal relative hyperaemia and the type with focal relative ischaemia (Table 4)

The angiograms in these groups revealed substantial differences In addition to the usually recognized signs of a vascular lesion the case with regional relative hypaemia had early filling of a vein or group of veins draining the same region The criterion used for early filling was the appearance of a normal vein at an earlier time than usual Such veins were generally present during the early arterial phase (Figs 1b 2b 3a and 4a) In addition a local accumulation of

Table 3

Result of analysis of 15 cases with fast focal flow and angiographic abnormalities — Figures in italics represent angiographically abnormal area

Patient	Interval between *onset of symptom to* examination	Range of *variation*	Regional fast flow values expressed as percentages of average flow				Flow values in lesion as percentages of flow in non lesion
A A	2	57	*158*	81	60	—	225
E J	1	103	*161*	102	78	58	193
F I	2	75	*133*	105	103	99	149
F N	*11*	*44*	*121*	*102*	*77*	—	135
Å O	17	36	*127*	102	96	99	134
S O	7	39	*119*	102	*99*	96	120
O O	29	30	118	100	94	88	112
						81	
G W	18	53	127	106	106	91	99
I P	5	40	*115*	109	103	*74*	88
Y B	*15*	*35*	*112*	*96*	*97*	*86*	*82*
J L	6	32	113	106	99	*81*	76
A O	—	40	118	103	78	—	*76*
F L	10	42	119	116	108	*90*	75
					88	*79*	
A B	12	*37*	118	101	*81*	—	*74*
B A	28	41	122	112	85	*80*	72

of brain stem lesions were also included in order to study the effect of such lesions upon rCBF in areas fed by the carotid artery

The material has been separated into three groups according to the roentgenologic findings (Table 1) Group I consists of cases with normal angiographic findings Group IIa is made up solely of cases with an expansive lesion demonstrated angiographically but without concomitant signs of occluded arteries The diagnosis of an arterial occlusion (group IIb) was made from the angiogram whenever arterial obstruction was directly seen or when its presence was indicated by signs of collateral circulation An expansive lesion was also present in some of these cases Cases with arterial stenoses of intracranial vessels are collected in group IIc Such changes may be accompanied by a decrease in the speed of passage of the medium peripheral to the stenoses A few cases had a local slow contrast passage of the medium as the only angiographic abnormality, this finding was used as a criterion of 'invisible stenoses and such cases were also referred to group IIc

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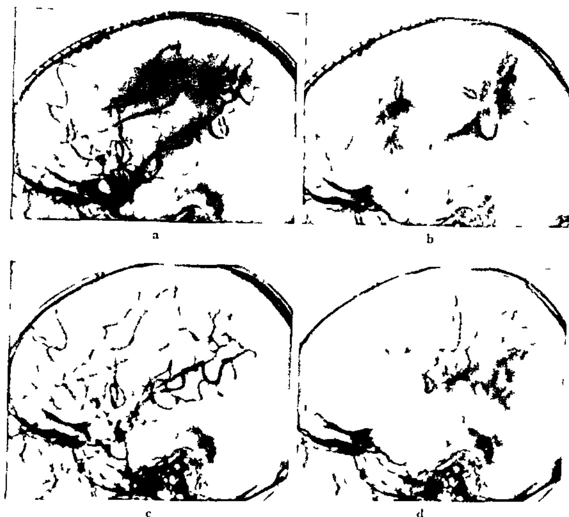


Fig 1 a) Multiple emboli (→) b) Late arterial phase Contrast medium remaining in occluded artery with simultaneous blush and early filling vein (→) c) and d) Repeat angiography No occlusion no capillary blush no early filling veins

contrast medium, a blush, was frequently noted in the same area (Figs 1b and 4a) These specific abnormalities were never present in cases with focal relative ischaemia or in those with the non focal type of flow

The close relationship between focal hyperaemia and the angiographic demonstration of a vein that was being filled early and a local accumulation of contrast medium has been further illustrated by repeat examinations in one and the same case, which is briefly described below (Fig 4)

This was a male, aged 69, with sudden right sided hemiplegia Left angiography disclosed occlusion of a small branch of the middle cerebral artery with signs of a local collateral circulation, early filling veins and an accumulation of

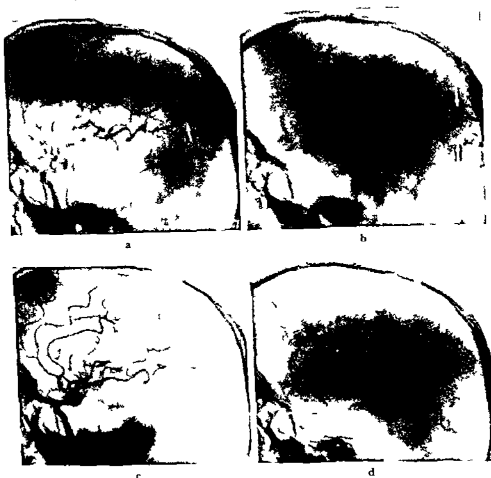


Fig 3 a) and b) Small expansive lesion in posterior part of temperoparietal region c) and d) Repeat examination after clinical improvement No expansion no early filling veins

contrast medium (Fig 4a) Further angiography one week later when the patient had almost recovered no longer revealed any of these changes (Fig 4b) Repeat determinations of the regional cerebral blood flow was also made in connection with the angiographic examinations In the first study it was found that the cerebral blood flow in the lesion was 51 7 (mean value) while the non lesion areas had a mean flow of 40 7 In the second study the blood flow in the lesion had decreased to 41 6 with flow in the non lesion areas of the same magnitude

These studies indicated that a local relative increase in cerebral blood flow angiographically is indicated by an accumulation of contrast medium and by early

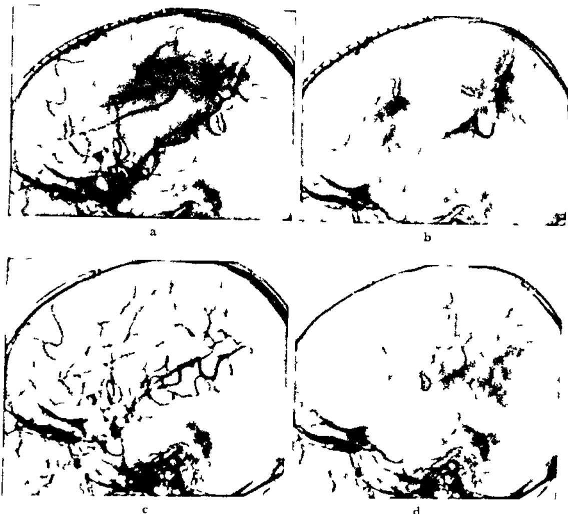


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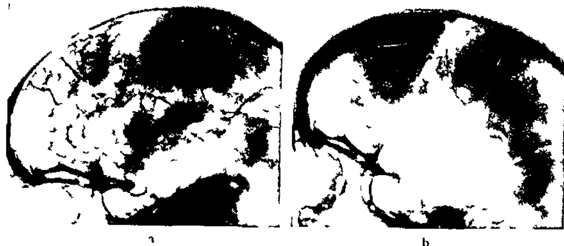
Discussion

It was reported in a previous investigation (CRONQVIST 1967) that the contrast medium Urografin 60 % used in our department for cerebral angiography causes an increase in the cerebral blood flow amounting to about 10 per cent. Angiography preceded the rCBF study in the present material and consequently the flow values might reasonably be expected to be proportionally elevated. It is however possible that contrast medium may cause specific effects within a focal lesion and this is now under further investigation. Preliminary results suggest that the main conclusions in this study are valid.

The size of the scintillation detectors and the collimation used in this study permits flow measurements only from fairly large circumscribed parts of the brain. It may be that this technique does not permit the detection of small focal lesions. This could probably account for the negative results of the rCBF studies in some cases with definite angiographic signs of a focal abnormality.

The roentgenologic criteria for separating the cases in different groups (Table 1) were usually clear cut. Those cases with a localized slow flow as the only angiographic finding may be subject to some doubt. Slow flow is admittedly not easy to define. A slow passage of contrast medium in an arterial sector of the hemisphere has been used as a diagnostic criterion for several years and good agreement between such focal retardation and the clinical signs has usually existed. The validity of the findings is further enhanced by the fact that focal slow transit of medium is common in cases of local stenosis or spasm (CRONQVIST & KÅGSTRÖM).

General rCBF effects. Previous experience has suggested that any focal lesion, whether tumour, intracerebral bleeding or occlusion, may cause a decrease in the cerebral blood flow in the affected hemisphere. This observation has been confirmed in the present investigation. It is also known (HØEDT RASMUSSEN & SKINHØJ 1964) that a decrease in rCBF may not only be confined to the hemisphere having a lesion but may also affect the contralateral side. Bilateral studies in four cases of the present material disclosed a decrease in rCBF in both hemispheres. The cause of this reduction in flow was not apparent. No correlation could be obtained in this series between the localization of the lesion and the degree of reduction in flow. The lesions were also of varying size, but the size itself did not determine the degree of reduction in flow. It is of particular interest that four cases with clinical signs of brain stem lesions all displayed a decrease of the cerebral blood flow in the supratentorial parts of the brain, although no clinical or angiographic signs of a lesion were present in these structures. These observations support the conclusion that a focal lesion may exert remote effects



a b

Fig 3 Intracerebral frontal haematoma a) Early filling veins b) Repeat examination after improvement Normal findings

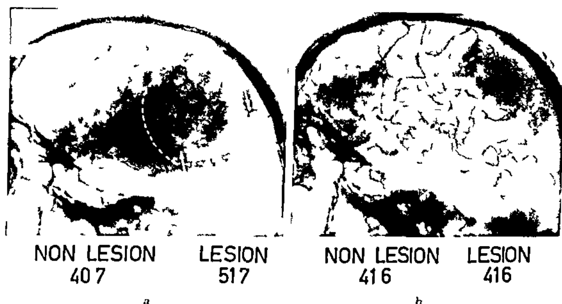


Fig 4 a) Slow circulation blush (→) and early venous filling peripheral to small occluded branch from the Sylvian arteries b) Repeat examination after recovery Canalization of artery normal flow no capillary blush no early vein The flow values in the lesion region and respectively in the non lesion region are given below the roentgenograms in ml/100 g/min

filling of veins The angiographic changes are transitory and an initial local high flow may decrease and reach a value corresponding to those found in other regions Furthermore a decreased flow may persist in spite of the complete disappearance of earlier angiographic changes

focus a fact confirmed by the observation of MEYER & DENNY BROWN (1955) of an increased pO in the tissue surrounding an ischaemic lesion A more complete survey of the pathologic features of cerebrovascular lesions has recently been given by INGVAR (1967)

Temporal pattern of rCBF changes The observation that regional relative hyperaemia (Figs 1 2 3 and 4) may be only transitory leads to the conclusion that the interval between the onset of symptoms and the angiographic or rCBF investigation may be of importance in interpreting the results in individual cases For cases with focal relative hyperaemia this interval was 6 6 days (1—17) while tho e with relative ischaemia had an interval of 14 3 days (5—29) The same interval for cases without signs of focal flow abnormality was 23 0 days (4—91) (Table 2) There are reasons to believe that the focal flow changes will pass through all these patterns of flow (Table 4) and eventually end up with an over all reduction i e with the non focal type of flow (Fig 4) If this decrease *in over all cerebral blood flow is a permanent one or if partial or complete* recovery may occur in due course is as yet unknown A more or less marked decrease in flow could still be detected in several cases of the present material examined more than two months after the onset of the acute phase Variations from case to case will probably always occur Further investigations aimed at clarifying this point are now in progress

Regional rCBF pattern The present study has also demonstrated that areas of relatively high flow occurred within areas with a relatively low flow (Table 5) In cases in which relative ischaemia corresponded to the angiographically demonstrated lesion the highest flow was present peripherally (Y B) On the other hand in cases with a regional relative hyperaemia it was evident that the lowest local focal flow was present within an area supplied by the same artery but peripherally to the lesion (S E J) The explanation may be the existence of an intracerebral steal syndrome in these cases

Differential diagnostics The angiographic demonstration of an accumulation of contrast medium and an early filling vein is of great value in the diagnosis of focal cerebrovascular lesions The findings may however also cause new diagnostic problems They are not specific but have occasionally been noted in cases of abscess (CHASE & SANCHEZ 1965) as well *as in those* of severe vasospasm after subarachnoid haemorrhage (CRONQVIST & KAGSTROM) Similar changes are frequently seen in cases of tumour and actually form the basis for a roentgenologic diagnosis especially as regards malignancy A cerebrovascular lesion must hence forth also be included *in the differential* diagnosis of tumours whenever early filling veins particularly when combined with a space occupying lesion (CRONQVIST 1966 CRONQVIST & LAROCHE 1967) are seen

Table 5

Fast flow values in the different regions expressed as percentages of average fast flow. — L/N: Fast flow in lesions (L) expressed as percentages of flow in other regions (N)

	Flow in the different regions				L/N
	I	II	III	IV	
S L J	*161*	102	78	58	193
G W	*115*	109	103	*74*	89
Y B	A 112	96	*9[illegible]*	*86*	*8[illegible]*

i.e. functional depression in distant cerebral areas with a general decrease of rCBF as a result (INGVAR, HAGGENDAHL, NILSSON et coll. 1964).

Focal rCBF effects. Although three main types of circulatory changes in the regional cerebral blood flow were observed in this series, some observations seem to suggest that more than one type of flow may occur in a single patient (Table 5, G W). It may be that the employment of an increased number of smaller probes will permit a more exact definition of regional changes.

Some of the specific roentgenologic observations made in the cases of focal hyperaemia described above have been previously reported upon, extensively by LANNER & ROSENGREN 1964, and by other authors (TAVERAS & WOOD 1964, ZATZ et coll. 1965, FERRIS et coll. 1966). Only the present rCBF technique has however made it possible to interpret the angiographic changes and demonstrate their association with regional cerebral hyperaemia. Available experimental data suggest that this hyperaemia may be secondary to tissue hypoxia induced by a cerebrovascular lesion. Cerebral autoregulation is abolished by hypoxia (HAGGENDAL & JOHANSSON (1965). Focal ischaemia may thus lead to a focal loss of autoregulative capacity, a fact proved by HØEDT RASMUSSEN, SKINHØJ, PAULSSON et coll. Furthermore, cerebral ischaemia causes not only a decrease in tissue pO_2 (MEYER & DENNY BROWN 1955), but also an increase in tissue pCO_2 (SIESJÖ 1961). These factors together will cause dilatation of the small vessels within an ischaemic area. Contrast medium within such vessels may be the explanation of the blush phenomenon. The presence of these dilated vessels also explains the rapid flow as demonstrated by the early filling of veins seen in the angiogram. These veins correspond to the "red veins" observed in relation to ischaemic regions in animal brains (WALTZ & SUNDT 1967). As in arteriovenous malformations, the red veins seem to contain blood with a high oxygen saturation. This implies the presence of cerebral hyperaemia in relation to an ischaemic

ZUSAMMENFASSUNG

Ein Material von 51 Fällen von fokalen cerebralen Gefässläsionen wurde mit Angiographie und Messung des lokalen Blutstromes untersucht. Die beiden Methoden ergaben neue Gesichtspunkte für derartige Läsionen und erbieten auch neue Kriterien in der Röntgenuntersuchung der fokalen cerbralen Ischämie. Die Signifikation einer Abnahme des cerebralen Blutstromes wird diskutiert.

RÉSUMÉ

L'auteur a examiné par angiographie et par mesure du débit sanguin cérébral regional 51 cas de lésions cérébrales focales vasculaires. Ces deux techniques ont fait découvrir de nouveaux caractères de ces lésions et font proposer de nouveaux critères radiologiques pour le diagnostic de l'ischémie cérébrale en foyer. L'auteur étudie la signification de la diminution du débit sanguin cérébral.

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The observation of similar angiographic changes in tumours and in cerebrovascular lesions, together with the fact that rCBF studies have demonstrated the presence of focal hyperaemia in both types of lesions (CRONQVIST & AGEE), may change our present concept of the nature of tumour veins It may be that some of these are due to tissue hypoxia, secondary to the occlusive ischaemic effect by the expansive lesion on the cerebral arteries

Conclusions

This investigation has verified earlier observations that a focal cerebrovascular lesion may cause a decrease in the cerebral blood flow not only in the hemisphere affected but also in distant cerebral areas In 17 of the 47 cases of this series focal *flow abnormalities have been registered*, seven of these consisting of relative focal hyperaemia and ten of relative focal ischaemia In addition to the well known angiographic signs of a cerebrovascular lesion, the seven first mentioned cases with focal hyperaemia presented characteristic early filling veins and accumulation of contrast medium in the area corresponding to the hyperaemia These changes were often the only angiographic signs of a vascular lesion An analysis of the intervals between the onset of symptoms and signs and the examination will determine the type of change in flow present in the individual case, as well as the type of angiographic pattern, with the hyperaemic type confined to the acute or subacute phase of the condition The finding of hyperaemia is of considerable physiologic interest and supports the present experimental interpretation of the events in focal cerebral ischaemia The concomitant angiographic findings bear differential diagnostic importance in relation to similar changes evident in cases of abscess, vasospasm and tumour

Acknowledgement

The investigation was supported by grants from Riksforeningen mot Cancer The author is indebted to D H Ingvar who placed the multiple channel *detector equipment at his* disposal The equipment was donated by the Wallenberg Foundation

SUMMARY

A material of 51 cases of focal cerebral vascular lesions was examined by angiography and by measurement of the regional cerebral blood flow These two procedures revealed new aspects concerning these lesions and the results indicated new roentgendiagnostic criteria in focal cerebral ischaemia The significance of decreased cerebral blood flow is discussed

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PNEUMOSINUS DILATANS

by

G LOMBARDI A PASSERINI and A CECCHINI

The term pneumosinus dilatans coined by BENJAMINS (1918) refers to the abnormal dilatation of a paranasal cavity containing air only It is an exceedingly rare disease little known to radiologists nearly all cases being published in journals of otorhinolaryngology or ophthalmology Even in recent treatises on craniology with the exception of those in German, only passing reference is made to the disease if it is mentioned at all It affects all the paranasal sinuses with differing incidence and consequences

Frontal sinuses These are the sinuses most affected In a review of the literature UNGERECHT (1964) collected 39 cases 38 men and 1 woman with an age range of 15 to 50 though the majority were between 20 and 40

Pneumosinus usually presents as a bulge above the orbital margin The bulge is often large and disfiguring There may be no other trouble or there may be headache or painful local tension (HARRISON & YOUNG 1955) Very rarely is it bilateral It affected the orbit in 3 cases displacing the eyeball to the point of causing double vision in Case 1 of UNGERECHT s (1964)

Maxillary sinuses These are the least affected We have found only 2 cases in the literature COTTE & NOVE JOSSERAND (1907) PSENNER (1963) Ac

Submitted for publicat on 23 October 1967

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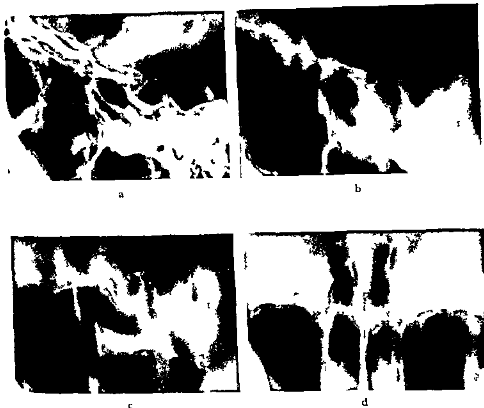


Fig 2 Pneumosinus sphenoidal a Swollen sphenoid cell has invaded the sella b) Lateral tomography Left contour of sella deformed by the pneumosinus c) Lateral tomography Right contour of sella normal d) Coronal tomography through the dorsum sellae Finger shaped projection of the left sphenoid cell is seen in the lumen of the sella

Roentgen examination of the skull (Fig 2) showed the sella to be deformed by an abnormal sphenoidal cell occupying a large part of the lumen and going beyond the dorsum Tomography revealed that the enlarged sphenoidal cell was developing upward and leftward sparing the right contour of the sella The walls were regular and the intersinusal septum was conserved but the transparency of the cavity was reduced

Encephalography (Fig 3) The ventricular cavities especially the third ventricle and its optic recesses were normal The sellar cisterns filled badly and at the level of the pneumosinus they were obliterated medially and laterally reduced to two thin flakes At operation the enlarged left sphenoidal

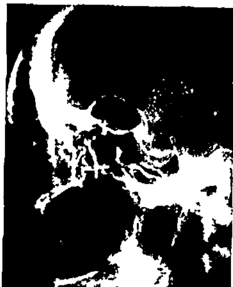


Fig 1 Pneumosinus dilatans ethmoidalis (Clinical signs of acromegaly with temporal hemianopsia and diminution of visual acuity From D AGATI in Radiol med 32 (1946) 151 Courtesy of the publisher)

cording to PSENNER, pneumosinus develops in the supero internal and anterior quadrant of the cavity as a hard protuberance covered with normal skin, and is usually diagnosed as an osteoma until subjected to roentgen examination

Anterior ethmoidal sinuses In this site pneumosinus tends to invade the orbit causing slowly progressive, irreducible, non pulsating exophthalmos We have collected 5 cases in the literature VAN DER HELM (1917), MEYER (1934), MONTRESOR (1954), MERCIER & JEZEGABEL (1958), FLOTTES et coll (1959)

Posterior ethmoidal and sphenoidal sinuses The ballooning of these cavities tends to develop inside the skull in the sellar region Mild forms are symptomless, but when the pneumosinus is large it behaves as a tumor causing damage to the optic pathways and sometimes giving rise to endocrine disorders (Fig 1) If pneumatisation extends to the optic foramina, thereby narrowing them, visual damage may be more severe (BEUTEL & TANZER 1963) We have traced *four symptomatic cases of this group HAJECK 1926 (1 case)* BENDESCU 1932 (1 case), AGATI 1946 (2 cases) To these we would add a personal case, which differs from the above in that a single sphenoidal cell was affected and the pneumosinus developed within the sella, sparing the *sphenoidal plane*

Our case was a male, aged 38, with a 3 year history of progressive weight gain (20 kg), polydipsia, polyuria, decreased libido and attacks of migraine Ophthalmologic examination while the patient was in hospital disclosed a slight decrease in visual acuity on both sides and bitemporal hemianopia



a



b



c



d

Fg 4 a) Sella tu c a defo med by a mmetr cal d elopment of the sphenoidal cell b) and c) Tomog aphy of the l ft and pectiv ly of the right cont ur of the sella d) Coronal tomography

4 The condition is excluded from other paranasal sinuses either because of anatomical malformations or because of inflammation of the surrounding cavities (sinusitis polyps) which prevent access

5 It contains air only

6 The macroscopic normality of the muscosa A few of the small number of cases examined histologically disclosed slight signs of inflammation

7 The absence of osteomyelitic changes in the bone walls which appear to be ballooned

8 The overwhelming preference for males of the 51 cases considered, only 3 were females

9 Age of onset the great majority of the cases occur in the 20 to 40 age range



Fig 3 Encephalography in the same case as shown in fig 2 The third ventricle is normal At the level of the pneumosinus the sellar cisterns are obliterated medially and reduced to two thin lateral flakes (arrows)

cell was found not to communicate with the other paranasal cavities It appeared to be empty at the opening and covered with slightly thickened mucosa, which was removed The texture and appearance of the underlying bone was normal The histologic examination brought forward mild evidence of non specific inflammation

Discussion

The notion of normality as applied to the paranasal sinuses is a highly elastic one Variations in shape and size of the individual cavities and in the degree to which they extend into the adjacent structures are so common that they must be regarded as representing the normal anatomy of the sinuses

Pneumosinus is, however, characterised by several features that mark it off from the normal pattern and permit identification Irrespective of the clinical consequences, which vary with the site, the features common to the group of 50 pneumosinuses collected from the literature and to the personal case are as follows

1 The dilatation is confined to one or to a few sinus cells

2 The condition may be stationary at some stages and then may suddenly develop

3 There is a predilection for certain sites the lateral recesses of the frontal sinuses, the superior recess of the maxillary sinus, the sellar region in the spheno ethmoidal locations, and the orbit in the anterior ethmoidal locations

very probably connected with the meningioma To avoid confusion we prefer to speak of 'blistering', a descriptive word used in the English literature that does not imply any pathogenetic definitions or limitations (compare with Fig 5)

In the literature the hyperpneumatisation of the paranasal cavities that is observed in severe cerebral palsy dating back to early infancy is often associated with pneumosinus Actually the two have nothing in common Overdevelopment of the sinuses occurs ex vacuo and has a compensating function It usually extends to all the paranasal cavities on the affected side and is accompanied by other cranial deformations and more or less marked signs of clinical palsy

Periorbital sinuses that dilate to fill the void left by enucleation of the eye performed in the first years of life and not corrected by prostheses occur by the same mechanism

All workers emphasise that it is possible to mistake a pneumosinus for a mucocele and in fact not a few pneumosinuses especially frontal and anterior ethmoidal ones have been operated on with this diagnosis This is mainly due to the rarity of the condition and hence to unfamiliarity with it Pneumosinus does not cause increased bone density or destructive changes of its walls and the original septa of the cavities are at least in part intact

SUMMARY

Pneumosinus dilatans is a rare disease marked by a circumscribed dilatation of the paranasal cavities containing air only It may affect any of the paranasal sinuses and in some sites may have neuro-ophthalmologic or endocrine consequences The incidence distribution and characteristics of 50 cases collected from the literature are analysed and one new case of sphenoidal pneumosinus dilatans is described

ZUSAMMENFASSUNG

Pneumosinus dilatans ist selten vorkommend und durch begrenzte Dilatation der Nasennebenhohlen die nur mit Luft gefullt sind gekennzeichnet Jede der Nasennebenhohlen kann angegriffen werden und dabei in spezifischen Regionen neuro-ophthalmologische oder endokrine Folgeerscheinungen hervorbringen Frequenz Verteilung und charakteristische Erscheinungen in 50 in der Literatur angegebenen Fallen werden analysiert Ein neuer Fall von Pneumosinus dilatans sphenoidalis wird beschrieben

RÉSUMÉ

Le pneumosinus dilatans est une affection tres rare marquée par une dilatation circonscrite des cavités paranasales ne contenant que de l air Il peut toucher n importe lequel des sinus paranasaux et dans certaines localisations il peut avoir des conséquences neuro-ophtalmologi



Fig 5 Meningiomas of the spheno ethmoidal plane illustrating blistering

Several hypotheses have been advanced to explain the disease Some have been discarded whilst others are still being discussed The idea that pneumosinus is due to an aerobic germ infection or that it is the outcome of a spontaneously emptied mucocele (HARRISON & YOUNG 1955) or the idea that it is due to intrasinusal hypertension have all been discarded The current view tends to be that several factors are at work (OLTERSDORF 1953, PIQUET 1960, UNGERECHT 1964) an existing malformation, chronic inflammatory changes in the surrounding sinuses that exclude the pneumosinus cavity and stimulate the pneumatisation power of the subepithelial layers of the mucosa, hormonal factors (DE STEFANI 1957), which in other pathologic conditions such as acromegaly, lead to overdevelopment of the paranasal cavities even after they are fully grown

Pneumosinus is connected with some diagnostic problems The first is how to establish a line of demarcation between the extreme limit of normal and the pathologic Small bulges quite without pathologic significance (PSENNER 1951) may develop along the inner contour of the sella In the case of Fig 1, clinically symptom free a sphenoidal cell had developed inside the sella In this, as in similar cases, only its further growth and/or the onset of clinical disturbances might justify the diagnosis of pneumosinus

Another problem is the connexions with meningioma which, in the opinion of some workers (SCHULLER 1930 STANKA 1933, MAYER 1954 PSENNER 1963), go beyond mere coincidence Ectasia of the sinuses demarcated by varying degrees of increased bone density was a finding in thirteen (38 %) of the 34 meningiomas of the tuberculum sellae and in eight (20 %) of the 40 meningiomas of the olfactory grooves operated on at this hospital (LOMBARDI 1967) Such a high incidence contrasts with the rarity of pneumosinus When it is considered that no other tumor gives rise to this deformation it is reasonable to suppose that there is a different mechanism of origin

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ques ou endocraniennes Les auteurs analysent la fréquence la *distribution et les caractères* de 50 cas de pneumosinus dilatans recueillis dans la littérature et decrivent un nouveau cas de pneumosinus dilatans sphenoidal

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MIMER III AND ROTATING CHAIR

by

G FREDZELL T GREITZ A GREPE and L HOLMSTROM

The precision in projection required in neuroradiology was emphasized already by LYSHOLM and resulted in his design in 1925 of the precision instrument for skull radiography When rapid serial cerebral angiography was introduced in the ninteen fifties the need for new equipment became apparent and this led to the construction of the Mimer (FREDZELL & LINDGREN) This unit was based on the same radiographic principles of projection as the Lysholm unit but offered greater flexibility for direction of the central beam towards a stationary film and the object table could in addition be replaced by a biplane cut film changer (SJOGREN & FREDZELL)

Developments in image intensification and transmission have created new possibilities for the application of fluoroscopy in connection with encephalography and myelography There is also a trend towards increasing use of tomography in such examinations This tendency has hitherto been restrained by the lack of an easily manoeuvrable unit especially for use in encephalography Tomography should in our opinion not be considered as a separate examination but should rather be used as a complementary radiographic technique comparable to the election of high or low kilovoltage It therefore should be possible to apply

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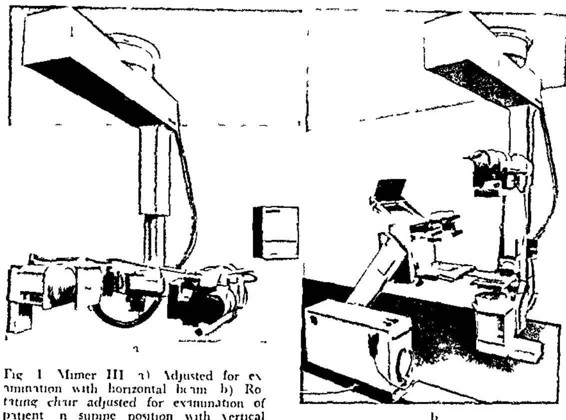


Fig. 1. Mimer III. a) Adjusted for examination with horizontal beam. b) Rotating chair adjusted for examination of patient in supine position with vertical beam.

tomography as well as fluoroscopy with as little effort and time lag as an alteration of kilovoltage.

It has for technical reasons been considered desirable to have access to an entity of equipment in which the roentgen tube, cassette holder, image intensifier and device for tomography are permanently in position for use. This is achieved by the design of a U arm which carries the tube at one end and the cassette holder and the image intensifier at the other. By means of suitably constructed supporting arms the central ray can be adjusted in any direction in relation to the object to be examined, which can be placed at the centre of rotation. The location of the object at the centre of rotation was recommended by DULAC (1956) especially for radiography of the ear, and was applied in the Princeps.

Gravity plays a role in the distribution of contrast medium and the patient must be placed in a certain position since the region to be examined is given and cannot be altered. To achieve the predetermined positioning it is usually sufficient to rotate the patient about his long axis. However, when symmetrical filling must be maintained in encephalography and ventriculography, rotation

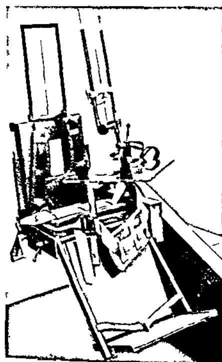


Fig 2 Rotating chair table (RCT 2) with supports and strappings used in encephalography and ventriculography

about a transverse axis is preferable This is the situation in ventriculography of the posterior fossa and when bilateral filling of the temporal horn is required Devices for rotation of the patient have been designed with these purposes in mind (POTTS & TAVERAS 1964 POTTS 1965) Problems of a similar kind are encountered in myelography when considerable tilts around the horizontal transverse axis may be required The demands for equipment to support the patient during the above mentioned neuroradiologic procedures are thus similar enough to justify the construction of a rotational unit equally suitable for all these purposes In the development of a new roentgen stand according to the requirements mentioned it is necessary to consider the demands on the rotating support of the patient and vice versa It has therefore been considered logical to arrange for a parallel construction of both units

Technical description of Mimer III and the rotating chair table

Mimer III The pattern of movement of the roentgen tube introduced in 1959 with the first Mimer stand is maintained in Mimer III (Fig 1) The roentgen tube is suspended in two arms one of which the tube arm rotates about



Fig. 3. Patient positioned for TV fluoroscopy and air filling of posterior fossa during encephalography.

a horizontal axis and the other, the vertical arm, about a vertical axis. In this system of movement the central ray can be directed from any point on the surface of a sphere to its centre, which coincides with the intersection of the two axes. In Mimer III, the radius of the sphere is 80 cm. The tube arm is extended and carries a cassette holder and an image intensifier tube. The vertical arm is suspended from the ceiling and consists of two telescopic members which allow a vertical adjustment of 56 cm.

The cassette holder, which has a circular opening for TV fluoroscopy, and the image intensifier tube are not directly attached to the extended tube arm but via a third arm which can be tilted ± 20° in relation to the tube arm. This tilt is activated by a motor, which also controls a corresponding travel of the tube in order to achieve correct linear tomographic travel of the focal spot and cassette, or the image intensifier. Tomography may thus be performed with any directioning of the central ray. Three tomographic angles have been chosen, namely 10°, 15° and 30°. The exposure times are then 0.8, 1.3 and 3.0 seconds.

Tomographic fluoroscopy is provided since the image intensifier tube follows the cassette. Certain TV monitoring accessories, i.e. an image storage unit, are however necessary to make this kind of fluoroscopy useful. The position of the tomographic layer is indicated by a light pointer. All tomograms are magnified exactly 40 % and therefore offer the most accurate means of measuring the correct size of any detail.

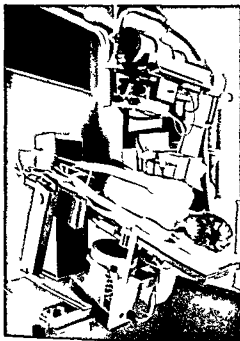


Fig 4 Mimer II and rotating chair t ble adjusted for use in gas m elo-grapl

Different holders including Lysholm multiline focussed grids are available for each cassette size The holder permits the cassette to be rotated ± 90° and tilted ± 40 The fo us film distance can be varied between 80 and 110 cm according to the location of the cassette holder along the tube arm A small object film distance may thus be obtained and annoying interference by the patient s neck or shoulder is avoided By tilting the cassette holder it is possible to obtain tomographic layers oblique to the central ray and at an angle that corresponds to the tilt of the cassette This is sometimes the only way to obtain the re juired location of the layer in the case of a given tomographic travel An example is a frontal cut parallel to the optic chiasm

An alternative to Mimer III is offered by Mimer II The arm system respon sible for the travel of the roentgen tube cassette and image intensifier are in Mimer II suspended in a heavy cantilever which travels vertically along a column attached to floor and wall The ceiling is left bare but the unit requires more floor space than Mimer III The two units are identical in function

The rotating chair (RCT 2) (Fig 2) consists of a seat which can be con verted to a flat table top and a rotating lever the position of which determines



Fig 3 Patient positioned for TV fluoroscopy and air filling of posterior fossa during encephalography

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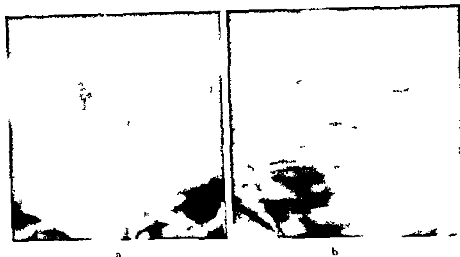


Fig 7 Ventriculography in a case of tumour of the fourth ventricle

on a track countersunk into the floor and transversely by the travel of the seat in relation to the rotating lever

Forehead and neck supports are provided for the head and the patient may be strapped to the seat A hole in the back of the chair is provided for lumbar puncture (Fig 3) The patient remains fastened to the chair in a sitting position during all phases of encephalography and ventriculography a complete somersault may be accomplished The speed of rotation of the patient may be continuously selected between 2 /second and 24° second i e one complete revolution in 15 seconds

The back of the chair for encephalography may be replaced with a larger one non obstructive to radiation which is used during myelography after the chair has been converted to a flat table top (Fig 4) The patient is suspended head down in a harness in which he may be turned into supine or prone position from the originally lateral recumbent position Linear tomography on a recumbent patient can be used all along the body with a travel parallel to the spine and from the head to the lumbar area with a travel transverse to the spine

The Mimer units in clinical practice

Mimer II and the rotating chair have for nearly two years been in daily use in the department of neuroradiology Mimer II is identical to Mimer III in its clinical application and our experiences which are based upon over one thousand examinations should therefore be valid for both units Furthermore we have

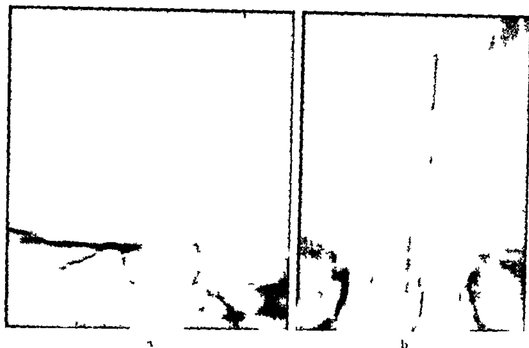


Fig. 5. Suprasellar extension of intrasellar tumour depicted by tomography.



Fig. 6. Tomographic examination of posterior fossa with encephalography.

the height (50 to 100 cm) above the floor level of the seat. There is also a base unit, which among other items contains a motor and gears for vertical adjustments parallel with the floor, by rotation of the lever, and for the free rotation of the seat. The chair table is adjustable longitudinally by the travel of the base

anaesthesia are preferably performed with the Mimer because of the high security offered Some minor disadvantages are that with the patient in horizontal position the areas below the cervical spine cannot be fluoroscoped with a horizontal beam direction The vertical adjustment of Mimer II should preferably have been larger e g in order to facilitate radiography in lateral projection with the head down The total time required for an encephalographic examination has not been shorter than with earlier equipments mainly because of the frequent use of tomography (Fig 6)

The rotating chair has been found to be a labour saving aid in the management of the patient during ventriculography especially for achieving and maintaining filling of the ventricular system of the posterior fossa (Fig 7) Gas myelography has been successfully carried out both by the suboccipital and lumbar routes according to the techniques described by LINDGREN (1939) and WESTBERG (1966) (Fig 8)

Daily work with Mimer II has shown the unit to be of value also outside of neuroradiologic work Instant fluoroscopy may be used at most skeletal and joint examinations as a control that optimal projection has been obtained e g during arthrography Examinations including tomography in the erect position may afford additional information concerning the spine hip joints and knee joints Mimer II is also a linear tomograph which fulfils the clinical demands for all kinds of tomography where the exposure time is of subordinate importance The excellent results obtained with Mimer II have convinced the authors that the characteristic principles of this unit should not be confined to neuroradiology but should be extended to other fields of diagnostic roentgenology

SUMMARY

The roentgendiagnostic unit Mimer III and the rotating chair table RCT 2 are described These offer great flexibility in the choice of beam direction and positioning of the patient as well as ready accessibility of TV fluoroscopy and linear tomography

ZUSAMMENFASSUNG

Die Röntgendiagnostik Einheit Mimer III mit Rotationsstuhl Tisch RCT 2 wird beschrieben Sie erbietet grosse Variationsmöglichkeiten in der Wahl der Strahlenrichtung und Lage des Patienten sowie unmittelbaren leichten Zugang für Fernsehdurchleuchtung und lineare Tomographie

RESUME

Description de l appareil de radiodiagnostic Mimer III et du fauteuil table rotatif RCT 2 Ils offrent une grande maniabilité pour le choix de la direction du rayonnement et de la mise en place du malade ainsi que la possibilité immediate d utiliser la radioscopie télévisée et la tomographie linéaire



Fig. 8. Gas myelography. Tomography with horizontal beam direction.

had several years of experience of corresponding examinations carried out with the Lysholm skull table, as well as with Mimer I. The examination routine in encephalography performed with Mimer II is basically the same as earlier, i.e. mainly identical with that described by LINDGREN (1949), with modifications introduced according to new possibilities.

One advantage with instant fluoroscopy is that it makes the initial and most critical phase of encephalography in the sitting position less time consuming. This is because it affords immediate information about the absence or presence of tonsillar herniation and about the degree of filling of the ventricular system and the subarachnoidal cisterns. The examination may therefore progress without delay. *Should a posterior fossa lesion be considered improbable*, the examination may be carried out immediately in the supine and prone positions. The patient is so well strapped in the chair that the lumbar puncture needle can be left in situ. The rigid and reliable fixation of the patient, combined with the movability of the unit increases the security since the head end can be instantly lowered in case of imminent herniation or fall in blood pressure.

The rotating chair does not restrict the patient to an examination in sitting, prone, or supine, positions. He may be placed in any intermediate position to obtain optimal filling of any part of the ventricular system, or of the subarachnoid cisterns. *This fact, combined with the possibility of performing tomographic* studies during all stages of the examination has permitted more information to be procured about previously less discernible structures (Fig. 5).

The design of the equipment is such that it does not always leave the patient within easy reach but this has been no problem either for the radiologist or for the anaesthetist when the examination has been performed under general anaesthesia. On the contrary, examinations of patients under general

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Fig 8 Gas myelography Tomography with horizontal beam direction

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